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Do They Read It? Well—Judge for Yourself

This Is a Copy of Our Paper That Has Gone the Rounds in the Plant of the American Rolling Mill Company

WHILE I count only as one on the staff of men who are trying to make this paper the best of its kind—I'm telling you right here that I am proud of this photograph, and it means a lot to me. It's a copy of an issue that has gone the rounds in the plant of the American Rolling Mill Company and is one of twenty-one others that have traveled the same course. Every page looks just as bad as the cover; torn up, thumb marked, and penciled here and there. These are the kinds of marks I understand for I know the thinking of men who carry a hunk of waste for a handkerchief and leave the mark of honest toil on white paper; men who have a job that bluff and inexperience cannot hold and that calls for head-scratching, arguments and sometimes disputes as to the best, quickest and cheapest way of doing things. While these men know what they are doing they are always glad to find a better way. Such men are the backbone of quality in American products and I feel proud of having traveled their road; when I have an opportunity to shake their greasy hands and talk to them, I'm right back home.

But this is a little off the point I want to make here. All practical papers that get down deep into the details of the work of men who are doing things are read, studied and kept for reference. But some are read more than others when the management of the works finds a way to make sure that the operating brains of their plants have a chance to see those papers that deal with the operating problems that are the everyday problems in the plant.

Such a plan has been formed by the American Rolling Mill Company and they have a reading table where their men can see all papers they are interested in, and after these papers have been on that table one week any particular one will be sent to the man for his own use if he will indicate a desire to see it. This is a good idea and it works, for the company advises that practical papers are now circulating among nearly 200 key men in its plants at Middletown, Ohio, Zanesville, Ohio and Ashland, Ky., and that several subscriptions are necessary to get them around before they are out of date.

It may be that you know of some other plan like this or an improvement on it. If so, drop me a line explaining your scheme so that we can pass it along and let others benefit thereby.

For INDUSTRIAL ENGINEER I can say that it's your paper in every sense and you can help us to make it just what you like to have it by your suggestions and requests for the information that you need most. But it's the discussions on material published and suggestions for additional data or facts that we like best for then we know that you read it—not just thumb it through—and we feel that we have a part in the job you are doing.

Practical Pete

A Glimpse Into the

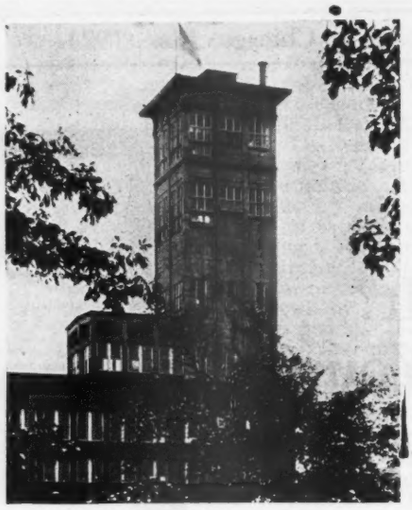
Works of The Winchester-Simmons Company

Which has added the manufacture of high-grade cutlery, tools and fishing tackle to its line of arms and ammunition, to utilize additional factory space erected to take care of demands for war production.

SOME IDEA of the extent of the manufacturing operations at the Winchester plant may be obtained from the diversity of its power equipment. The power plant is one of the largest industrial power plants in New England. In this plant is generated all of the electrical energy used in the factory for power, light and tempering.

The gas plant alone manufactures 600,000,000 cu. ft. of water gas and 1,700,000,000 cu. ft. of producer gas annually. This gas is used as fuel for generating over 9,000 hp. and, in addition, for annealing at the rolling mills and in the auger bit shop and as fuel in the heat-treating shop. Over 100,000 tons of coal are used each year to fire the 7,500-hp. boilers and for the manufacture of producer gas. The gas and steam plant has a capacity of 16,375 hp.

The manufacture of arms and ammunition, which is the product of the Winchester Repeating Arms Company, a subsidiary of The Winchester-Simmons Company, represents two widely separated lines of manufacture, but each requires a high degree of accuracy and skill. The value of these produced in 1923 was $25,000,000, practically all of which was used for sporting purposes. A repeating rifle or shotgun contains in addition to the carefully forged, bored and straightened barrel the intricate operating mechanism to load and eject the ammunition. All of this requires highly skilled handwork in its manufacture. This equipment must be reliable, as a sportsman's life may sometimes depend upon it. For this reason a gun often becomes very personal to its user.



This concrete structure is devoted exclusively to the manufacture of lead shot.

All materials are mixed and melted according to special formula at the top of the tower, nearly 225 ft. high. The molten metal is poured through a screen and after a drop of 190 ft., during which the pellets have been formed, the shot lands in a tank of water, is cooled and then cleaned and scoured. The shot is then automatically carried to selecting machines where the pellets are cascaded over a series of thirteen inclined glass plates which eliminate those having slight irregularities of size, finish or shape.

The Winchester Repeating Arms Company, which was the parent organization, was organized in 1866 with eighteen employees. This was a reorganization of The Volcanic Arms Company, established in 1855, which was in 1856 reorganized as the New Haven Arms Company. When the United States entered the World War, the force had grown to 6,000 employees and the plant occupied sixty acres. During the World War the Winchester plant was easily turned into war production and as the organization was skilled in this work, both plant and equipment were expanded to provide increased production. At the signing of the armistice, about 22,000 employees were operating 21,000 machines driven by 2,000 motors and were producing 2,500 military rifles and 2,000,000 cartridges daily in addition to the large number of bayonets, cannon primers and other war equipment, including Browning machine guns and rifles.

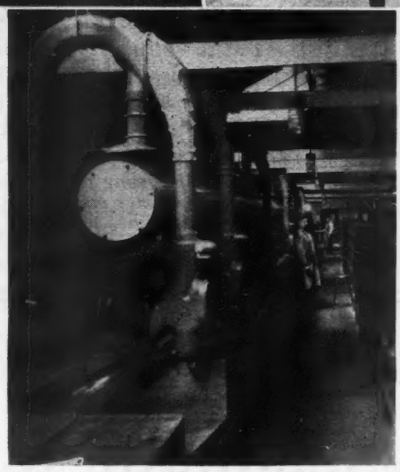
To use the extra plant and equipment it was decided to begin the manufacture of a line of cutlery and tools which, like arms, would have a strong personal appeal as they would be actually used by the purchaser. In addition, many of the manufacturing operations—forging, grinding, tempering and others—are required in both lines of production.

The present plant at New Haven, Conn., is devoted to the manufacture of arms, ammunition and some of the new hardware.

The original Winchester factory employed eighteen men. The present factory covers eighty-one acres of ground, and contains 3,500,000 sq. ft. of factory floor space. Over 22,000 were employed during the World War in the manufacture of arms and ammunition. At the signing of the armistice part of this space was turned over to the manufacture of cutlery, tools, fishing tackle, flashlights and batteries and other similar hardware.

Steps in the manufacture of knives and of cartridges.

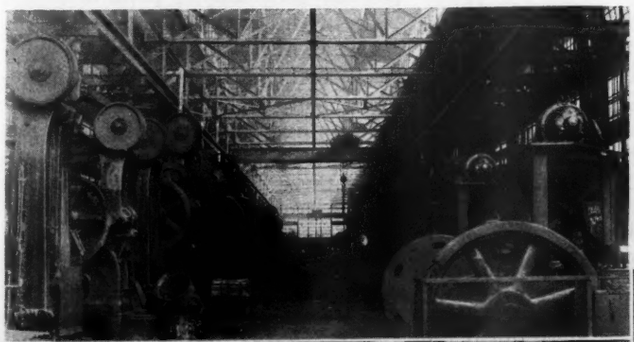
The semi-automatic machines (above) are used for wet grinding of knife blades. In addition, the knives are dry-ground and polished. With the exception of steel, all of the products used in the manufacture of the various lines of sporting goods and hardware supplied by this company, are processed from the raw materials in its own shop. For this, it has a modern rolling mill (upper right) which is used to roll down the ingots of nickel, copper and zinc, after these materials are mixed according to the specific formula and cast in strips for rolling. These products are used in the manufacture of cartridges, fishing tackle, pocket-knife lining, reels and other products. The illustration at the right shows the pneumatic tube for transporting powder from storage to the cartridge loading room.



Also, a flashlight battery, for example, requires a drawn zinc tube—an operation similar to the drawing of brass cartridge shells. Present day production requires about 1,500 tons of copper, 5,000 tons of steel and 8,500 tons of lead in addition to large quantities of zinc and nickel yearly.

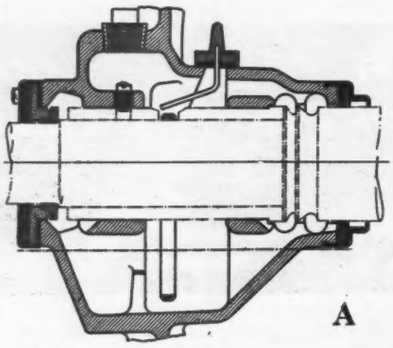
To get distribution, the Simmons Hardware Company was co-ordinated in the organization. The Winchester-Simmons Company is selling its new product exclusively to a group of about 6,000 hardware stores in the United States. Other lines, such as builders' and other miscellaneous ordinary hardware required, are purchased. The addition of this new line of hardware, such as cutlery, tools, fishing tackle and the like, has added fifty-three different lines of merchandise, including over 2,000 new items which contain more than 22,000 different components and require hundreds of thousands of fixtures, tools and gages for their manufacture. The extent of the tool department which manufactures all the tools, fixtures and gages used in the manufacture of these various products, indicates one of the big problems in adding a new line to an industry. The tool department occupies 75,000 sq. ft. and employs over 1,000 mechanics. The most important and the most accurate, of course, are the tools and gages required in the manufacture of gun parts.

The plant has a good record for continuity of service as over 3,500 employees have a record of over five years service and of these about 300 have been with the company over twenty-five years.



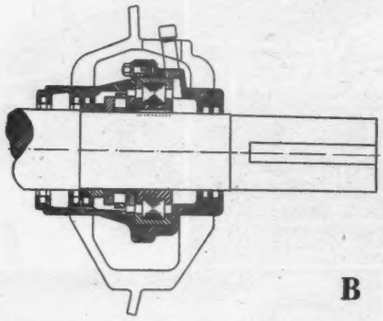
A few examples of the varieties of work in the manufacture of guns at the New Haven plant.

In the forge and hammer shop (left) the guns, rifles, axes, hatchets, knives, scissors, chisels and other forged tools are formed. While some of the hardware equipment can be ground or machined to a finish, many of the parts in gun and rifle manufacture must be carefully filed to shape by hand as shown in the illustration below. This is slow, careful work as each part must be absolutely accurate or made so that it will work perfectly. Another important step is the straightening of the rifle barrel, (lower left), as accuracy in shooting depends upon it.



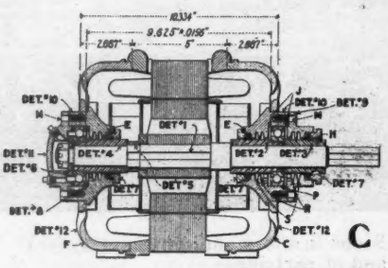
A

This improved design of sleeve bearing with leakproof devices to prevent escape of oil at high speeds, was described in an article in the March issue. In that article the improvements which have been made in sleeve bearings, with their advantages and pointers on their maintenance and care, were described.



B

How these roller bearings were installed in mill-type motors was described in an article in the April issue. The advantages resulting from the use of roller bearings and the troubles eliminated by using them in place of the sleeve bearings originally furnished with the motors, were set forth in detail.



C

The use of ball bearings mounted in dustproof housings, to eliminate the troubles encountered with sleeve bearings in motors operating in a foundry, was described in an article in the May issue. In that article complete details of the design of the housing and the method of installing the bearings were given.

Viewpoints of Manufacturers on

Possible Improvements in Bearing Service

And the Things to Consider in Connection with the Use of Sleeve, Ball and Roller Designs Under Varying Conditions in Mill and Factory Operation

By G. A. VAN BRUNT

Managing Editor, Industrial Engineer.

FOR MANY YEARS, plain or sleeve bearings were the only type in use and they have served their purpose well. However, with the development of modern, high-speed equipment and a more insistent demand that friction and other power losses be cut to a minimum, the attention of engineers and designers was directed to the problem of designing a form of bearing which would be superior in most, if not all, respects to the plain bearing. In particular it was desired to produce a bearing in which friction was reduced to the lowest possible value. That the problem is not new is evidenced by the fact that patents covering ball bearings were taken out upwards of sixty years ago. These bearings were crude compared to those of present-day design and are of theoretical rather than practical interest. The widespread, commercial use of anti-friction bearings has come about within the past twenty-five years, roughly.

INSPECTION AND CARE of bearings is an important feature of every maintenance crew's job. In some classes of service, for example, in cement mills, bearings probably receive more attention than any other mechanical, or electrical, element of the equipment used. Improvements in bearing service from the standpoint of reduced maintenance cost and increase in length of life under severe operating conditions are a matter of everyday interest to all operating men. In this article details are given showing what bearing manufacturers are doing to help in solving this problem.

The most severe of all tests, the test of service, has weeded out various imperfect designs so that at the present time there are two broad types of anti-friction bearings in general use: ball bearings and roller bearings. The various designs of ball and roller bearings with directions for their installation were described in the September 1922 issue of INDUSTRIAL ENGINEER. When properly applied, both of these classes of bearings have given good service.

A great deal of development work has also been done on plain bearings, both in the way of improving the qualities of the metal from which the bearings are made and in improvements in the design of the bearing and its housing.

The user of bearings has, therefore, three types of bearings to choose from: plain, ball and roller bearings. In order to present to the readers of INDUSTRIAL ENGINEER the advantages and possibilities of each of these types of bearings from the standpoint of meeting the wide range of service conditions in industrial work, these points have been discussed in articles that have appeared in recent issues. For example, in the March issue, R. Pruger discussed some of the troubles which have been experienced with sleeve bearings and showed how these have been minimized or entirely overcome by correct design of the bearing and by proper oiling and care. In his conclusion, he pointed out that when correct principles are applied to the design of sleeve bearings,

with high standards of manufacture and maintenance, these bearings possess many advantages from the standpoint of economy.

In the April issue, L. J. Hess outlined his experience in the application and operation of 300 sets of roller bearings on mill-type motors in steel mill service. After the successful solution of certain mechanical problems involved in the installation of roller bearings in sleeve-bearing motors his experience showed that roller bearings possess the following advantages:

(1) Electrical repairs to commutators and windings are greatly reduced because at least 50 per cent of these troubles start from oil and grease working their way onto the commutator and front V-ring. With roller bearings the grease is entirely confined within the bearing shell. (2) Commutator wear is materially reduced because there is no jumping of the armature due to loose bearings with its tendency to cause flashing and consequent flat spots. The shafts are longer lived because the only wear on them is in the keyways. (3) The fact that the armature is held constantly in the center of the magnetic field helps to make the current distribution uniform, thereby relieving the equalizer connections of abnormal duty. (4) Broken bands due to rubbing are unknown. (5) Pinions are kept accurately in mesh and crowding of the teeth with constant strain and vibration is eliminated. (6) Expense of inspection is somewhat reduced due to better commutation, and less attention is required for lubrication. (7) The cost of lubricants is reduced to an almost negligible figure as the bearings consume practically no grease. (8) Because of the reduction in repairs it follows that not only are labor and loss of time in the mills during armature changes reduced, but also the delay time charged against the electricians.

Robert W. Drake in the May issue showed how relief from serious bearing trouble was sought and found in the application of ball bearings in small motors. These motors operated molding machines in a foundry and were subjected to excessive amounts of sand and grit. Under these circumstances the sleeve bearings with which these motors were equipped had an average life of six weeks, although many failed in a week or less. The loss in production delays and the cost of frequent replacements of bearings were intolerably high and after a good deal of experimenting ball bearings enclosed in a dustproof housing were installed in a total of about forty motors, with very satisfactory results. There have been no bearing failures and little or no maintenance expense. Some of these bearings have run for three years without regreasing.

Under proper conditions sleeve, roller or ball bearings will give satisfactory service. The selection of the type of bearing to be used for a given application must be predicated on a careful study of the service conditions and requirements of the drive in question. Compared with the others, each of these types of bearings has advantages and disadvantages. From the standpoint of their application to motors, the advantages and disadvantages of the anti-friction bearings were summarized as follows by A. M. MacCutcheon in a paper presented before the Association of Iron and Steel Electrical Engineers:

Advantages

(1) Absence of oil. By various steel mill electrical engineers, it has been estimated that the presence of oil is responsible for 60 to 90 per cent of their motor troubles, causing injury to the insulation, shorting of commutator bars, gumming of commutators, causing collection of dust and a general unsightly condition. The lubricant is more easily retained in a ball or roller bearing than in a sleeve bearing.

(2) Reduction in maintenance cost. Much less frequent attention need be given to the lubrication of a ball or roller bearing. The weight of the evidence received from the users of anti-friction bearing motors is to the effect that failure of bearings is very much less frequent than on oil-ring bearing motors.

(3) Reduced wear of the bearing, resulting in much less frequent renewal of the bearings due to the lowering of the rotor and the consequent decreased air gap at the bottom. This consideration is of particular importance on induction motors with their small air gaps.

(4) Increased efficiency. A record was presented of a test on a 3-hp., 1,500-r.p.m. induction motor. Three motors were used, one equipped with ring-oiler bearings, another with waste-packed bearings and a third with ball bearings. The test showed the following efficiency:

Ring-oiling bearings	81½ per cent
Waste packed	80½ per cent
Ball bearing	84 per cent

(5) A considerably decreased torque is necessary at starting. In the case of an oil-ring bearing, sufficient torque must be applied to break the contact of the shaft on the bearing metal before the oil film is established.

(6) Anti-friction bearings make possible a considerable reduction in the overall length and in the weight of the end housing. Babbitted bearings are usually designed with the bearing length two and one-half or three times the diameter of the shaft, whereas the length of the ball bearings is usually not over one-third of the shaft diameter. A ball bearing manufacturer has advised that a tabulation of standard motor sizes proved that the overall length can be reduced on an average of 15 to 20 per cent by using ball bearings.

(7) The information received from the railroads, the Government and the steel mills which have experimented with anti-friction bearings, indicates that these bearings have been successful and this experience should certainly be classed as a strong argument for the use of such bearings.

Disadvantages

(1) Cost. The first cost of the motor will be greater and two lines of motors will have to be manufactured as long as the users of motors are not unanimous in their opinion. If the user changes to the anti-friction type of bearing, it will be necessary for him to carry two lines of spares until all of the oil-ring bearing motors have worn out or been replaced.

(2) Difficulty in making replacements. It does not seem that it will ever be possible to replace a ball bearing as easily as an oil-ring bearing. To secure proper operation, it is necessary that the inner race be tight on the shaft, which prevents its easy removal. For steel mill operation, it may be necessary to carry complete armature with bearings assembled. This would certainly not be justified unless the reduction in the number of bearing troubles more than compensated for this extra expense.

(3) The care which is necessary in successfully mounting anti-friction bearings and assembling the armature in the frame. The oil-ring type of bearing does not require the careful assembly needful with an anti-friction bearing.

(4) It is essential to very carefully protect anti-friction bearings in handling and installation. This is

readily recognized as a disadvantage in the steel plants.

(5) The workman in the steel mill is unfamiliar with the mounting of anti-friction bearings and the assembly of such motors. This must be charged up as a disadvantage until such time as the average worker becomes sufficiently familiar with this type of motor to be able to disassemble it without any difficulty or detailed instruction.

(6) In cases of armature grounding, current may pass through the balls or rollers and the races, causing pitting; in extreme cases, actually fusing race to balls or rolls.

(7) Under emergency conditions where a spare bearing is not available, the oil-ring type of bearing may be babbitted or cast by any reasonably good workman. This is not true of the anti-friction type.

(8) The strongest argument against the use of anti-friction bearings or any other device is the fact that it has not been thoroughly proven under actual operating conditions. Whether or not the anti-friction bearing will stand up as well as oil-ring bearings under shock and unusual load conditions, has not yet been conclusively demonstrated. Until the case for the anti-friction bearings has been firmly established, they must be recognized as being on trial.

The following comments have been received from manufacturers of bearing metals, and anti-friction bearings in response to an invitation by INDUSTRIAL ENGINEER to give their suggestions on possible improvements in bearing operation and the points to consider when installing these bearings.

Comments That Have Been Received From Manufacturers of Bearings

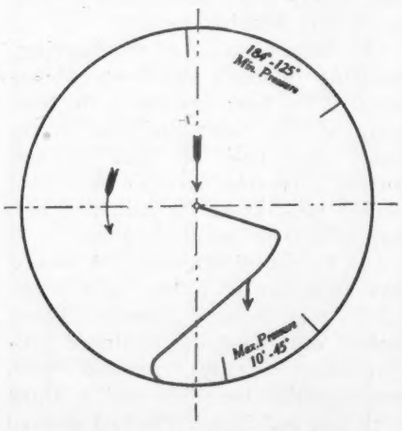
Relating to Improvements in Bearing Operation and Practical Points to Consider When Installing Sleeve and Anti-Friction Bearings in Equipment

C. H. Bierbaum, Vice-President and Consulting Engineer, Lumen Bearing Co., Buffalo, N. Y.: The relative merits of sliding-surface and rolling-surface bearings have been very ably discussed in two recent numbers of INDUSTRIAL ENGINEER. Mr. R. Pruger, in the March issue, very ably presented the sliding-surface or sleeve bearing, and Mr. L. J. Hess, in the April issue, the rolling-surface, or ball and roller bearings; each one discussing his topic from an intensely practical viewpoint. The reading of the two articles puts one into the compromising frame of mind in which the young judge found himself after his first hearing, when he decided "you both got the case." In fact they both have. There is a field in which each kind is best.

The very nature of the production of all the rolling-surface bearings required that they should receive more initial thought and study than the apparently simple forms of sliding-surface bearings; in fact the production of the former, from the beginning, has been a specialized one, whereas the latter have been "made by almost anyone, from almost anything, for almost everything."

There is no sharp dividing line between the respective fields for the two kinds of bearings; this is brought out clearly by the fact that different users often disagree in their preference for one or the other when considering specific bearing requirements, and also for the reason that we find users changing from one to the other, and after years of trial again returning to their first choice.

It is, therefore, evident that a lack of general dissemination of the technical knowledge relating to sliding-surface bearings, has, and is, constantly mitigating against the proper use of the same. The first real scientific study on the subject of bearings was begun by Tower, forty years ago. It was he who first demonstrated that a film of oil could carry the load of a bearing without having metallic contact between the bearing surfaces. He showed that certain definite and immutable laws exist which govern the forming and the maintaining of an oil film. It is, therefore, evident that unless a machine designer or a mechanic fitting up a bearing understands these laws, he is working in the dark, and his results will be erratic and questionable.



Movement of center line of journal and position of points of minimum and maximum pressure on oil film in bearing when journal is rotated and load gradually applied.

These pioneer and subsequent studies have shown that for proper lubrication a definite amount of clearance or space around the journal must be provided as a space in which the oil film should form; that without this space it is impossible for the film to form. It has also been shown that if the bearing is not a complete cylinder the advance edge of the same should be chamfered or rounded off in order to permit the film to form. An increase of speed increases the thickness of oil film if temperature and other conditions remain constant and provided that sufficient space or clearance has been allowed. The use of an oil of high viscosity requires that more clearance be provided for a proper film to form. A common rule to follow for ordinary machinery is that of allowing a clearance of 0.001 in. plus an additional 0.001 for every inch of diameter of journal. The load carrying capacity of a bearing is not necessarily proportionate to its projected area, since a large unbroken area is capable of supporting a greater pressure per unit area than a smaller one. The function of oil grooves is to supply and distribute the oil to the bearing; they should not be excessive. Oil grooves can be made a positive detriment to a bearing by being excessive or in that part of the bearing in which the film is subjected to maximum pressure, in which case they become effective drains for carrying off the oil film.

The accompanying illustration is an interesting and profitable study of the behavior of the journal and bearing and that of its oil film. To begin with, let us assume that we have a journal 3 in. in diameter. According to the foregoing rule of clearances that would have a total clearance of 0.004. in. That is, the center point of the journal will then have enough freedom to be able to describe a circle 0.004 in. in diameter, and at the same time be able to assume any position within this circle. In the diagram let the diameter of the outer circle be equal to 0.004 in. We will then be able to plot all the movements of the center of the journal within this circle. After lubrication rotate the journal in the direction of the curved arrow, without having any load upon the same (not even its own weight); the center of the journal will then assume a position in the center of the circle, having an oil film of even thickness throughout its entire circumference. Now, if we continue the rotation of the journal and gradually apply a load in the direction of the vertical arrow, the center point of the journal will move along a line making an angle of 72 deg. with the vertical, as the load is gradually increased. This line may be called the load line, which the center of the journal follows to a distance equal to one-fourth the amount of clearance which, in this case, would be 0.001 in. Here the oil film is ruptured, and the maximum carrying capacity of the bearing will have been reached.

When a bearing is at rest, the loaded journal will be in metallic contact with the bearing at the lower point of its vertical diameter. As rotation begins, rolling of the journal upon the bearing occurs and continues to a point called the angle of repose, where slipping begins and when an oil film begins to form, at the same time. From here it

follows the curved line and then assumes a position upon the load line corresponding to the amount of load which it carries.

Very important features brought out in this diagram, are the location of the arcs where maximum and minimum pressure occur upon the oil film. While a load is being gradually applied, the center point of the journal moves along the load line, a maximum pressure begins to develop at a point 10 deg. from the foot of the vertical diameter(measuring all degrees in a counter-clockwise direction). With an increasing application of load upon the journal, this point of maximum pressure gradually shifts to a point of 45 deg., beginning with zero, to that necessary for the rupture of the oil film. In the same manner and at the same time a minimum pressure is being developed at a point of 184 deg., and as the load is increased, this point of minimum pressure gradually shifts to 125 deg., and there constitutes the minimum pressure at the time of oil film rupture; its value changing from atmospheric pressure at first to a negative pressure or distinct suction.

This study clearly shows where the oil grooves **should be placed**, and where they **should not be placed** for best service conditions.

Donald L. Colwell, Metallurgist, Stewart Mfg. Corp., Chicago, Ill.: One commonly neglected cause of a great many sleeve bearing troubles is the choice of the wrong bearing metal. Much attention is paid to the design of the bearing, with particular emphasis on means of lubrication, and many and various are the devices for providing and maintaining a continuous oil film between the journal and the sleeve.

When it is possible to design a bearing that will automatically keep a continuous oil film between the bearing and the shaft without undue loss of oil, the problems of the engineer are greatly simplified. Such a bearing, however, is not often found. When such a bearing is found, it is subject to the human element; for its oil cup must not run dry. It is necessary, therefore, to construct the bearing of a material that will cause the minimum amount of damage if the lubrication does fail.

Let us consider a simple sleeve bearing supporting a steel shaft. In the first place, no matter how carefully the shaft is ground and the bearing fitted, when the shaft first revolves in the sleeves it will rest on a few "high spots," and bridge over the intervening areas. This causes an unduly high load to be placed on the high spots of the bearing metal, and usually the oil film at these points is broken. This continues until the shaft has either pressed these high spots down, or worn them away to the lower levels of the bearing. If the bearing material is plastic enough, they will be pressed into place and the shaft will rest uniformly on the whole bearing. If the bearing material is not plastic, the high spots will remain until they are worn down by the shaft, and often the shaft itself is worn somewhat by the process. This introduces fine particles of bearing metal, and sometimes steel, into the oil, with ruinous effect on its lubricating value. It is necessary, therefore, to make the bearing as plastic as possible so that the high spots in the new bearing will be squeezed down, rather than worn away.

After this bearing is properly "worn in," it will function nicely as long as the oil film separates it from the shaft. However, if the lubrication is faulty and the oil film broken there is metallic contact between the revolving piece of steel and bearing metal; that is, a steel surface is rubbing against another metallic surface with a greater or less velocity. This causes a certain amount of energy which revolves the shaft to be used in overcoming the friction; this energy reappears in the form of heat. The amount of energy used in overcoming friction depends on the friction developed and this, in turn, depends in part on the co-efficient of friction of the bearing material. It is advisable, then, to secure a bearing metal with a low co-efficient of friction.

The heat developing from the friction can do harm in many ways, but we will neglect the harm it might do to certain forms of apparatus and consider only the effect of high bearing temperature on the bearing itself, or the shaft. It must be remembered that in addition to these limitations, the maximum temperature allowable is limited by the application of the bearing in the apparatus. High bearing temperature can harm the shaft only if high enough to draw the temper, if the shaft is hardened, but it might seriously soften the bearing and lower its load bearing qualities. The table shows the effect of temperature upon the hardness of several grades of white bearing metal, including both tin- and lead-base alloys. It is advisable, therefore, to secure a bearing material which will not soften under heat.

It is seen, then, that the following considerations should influence the selection of a sleeve bearing material, after the requirements of physical strength, machinability, etc., have been met: (1) The material should be plastic enough to fit itself to the shaft without excessive wear. (2) It should have a low co-efficient of friction. (3) It should withstand heat without serious softening. (4) It should also be hard enough to resist excessive wear.

In general, there are three types of bearing metal in use today; the white bearing metals, the bronzes, and the copper-lead metals. The white metals are usually either lead or tin base, although zinc-base metals have been used. The lead base metals are hardened by the addition of antimony, tin, or copper, or any two of these, or all three. The strength and hardness of the metal depend on the amount of hardener added, but the following analysis, that of specification No. 14 of the Society of Automotive Engineers illustrates the class:

Metal	Per Cent.
Tin	9.25 to 10.15
Antimony	14.00 to 16.00
Lead (max.)	76.00
Copper	0.50
Arsenic (max.)	0.20
Zinc and Aluminum	None

The tin-base metals are also hardened by antimony and copper and sometimes lead is added. The following S. A. E. specifications, No. 11 and No. 12 are representative of the tin-base bearing metals:

	Spec. No. 11	Spec. No. 12
Metal	Per Cent.	Per Cent.
Antimony	6.00 to 7.50	9.50 to 11.50
Copper	5.00 to 6.50	2.25 to 3.75
Tin (min.)	86.00	59.50
Lead (max.)	0.35	26.00
Iron (max.)	0.08	0.08
Bismuth (max.)	0.08	0.08
Arsenic (max.)	0.10	....
Zinc and Aluminum	None	None

Specification No. 11 is representative of the so-called genuine babbitt metals, first used by Isaac Babbitt, and is a high-grade bearing metal. The copper and antimony are often varied considerably from these figures for different uses.

The microstructure of a genuine babbitt metal is shown in the upper portion of Fig. 1. As the molten metal cools, the antimony crystallizes in the cube-shaped crystals of composition

Physical Properties of Some White Bearing Metals at Temperatures Above Normal

Bearing Metal	Property	Temperature 25° C 77° F	50° C 122°F	75° C 167° F	100° C 212° F
S.A.E. Spec. No. 11 Copper 5.75% Antimony 6.75% Tin 87.50%	Brinell hardness	22.3	18.2	14.8	11.3
	Yield point	5,750 lb. per sq. in.	5,000	4,250	3,350
	Ultimate strength	16,425 lb. per sq. in.	12,175	10,100	7,725
S.A.E. Spec. No. 12 Copper 3.00% Antimony 10.50% Lead 25.00% Tin 61.50%	Brinell hardness	22.4	15.8	11.3	7.5
	Yield point	4,700 lb. per sq. in.	3,650	2,900	2,150
	Ultimate strength	13,685 lb. per sq. in.	10,035	7,845	6,045
S.A.E. Spec. No. 13 Tin 5.00% Antimony 10.00% Lead 85.00%	Brinell hardness	19.7	16.8	11.4	8.2
	Yield point	3,750 lb. per sq. in.	2,650	2,250	1,550
	Ultimate strength	15,020 lb. per sq. in.	11,275	7,920	4,770

Note—These values are taken from Bureau of Standards Technologic Paper No. 188, by Freeman and Woodward.

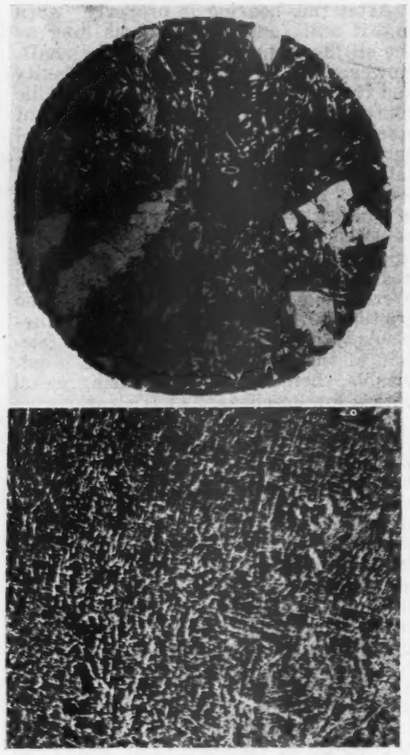


Fig. 1 — Microstructure of two types of bearing metals.

Above, structure of genuine babbitt metal which was cooled slowly to favor the development of large crystals. The large, cube-shaped crystals are an alloy of tin and antimony. The copper crystallizes out in pointed or hook-shaped crystals which are composed of, roughly, three parts of copper and one part of tin. The crystals are shown here as they appear when magnified 80 diameters. The lower photograph shows the structure of a copper-lead bearing metal. The long, tree-like crystals, which appear white in the photograph, are composed of practically pure copper. The material, shown as dark areas, between the copper crystals is mostly lead. This photograph was taken under a magnification of 20 diameters.

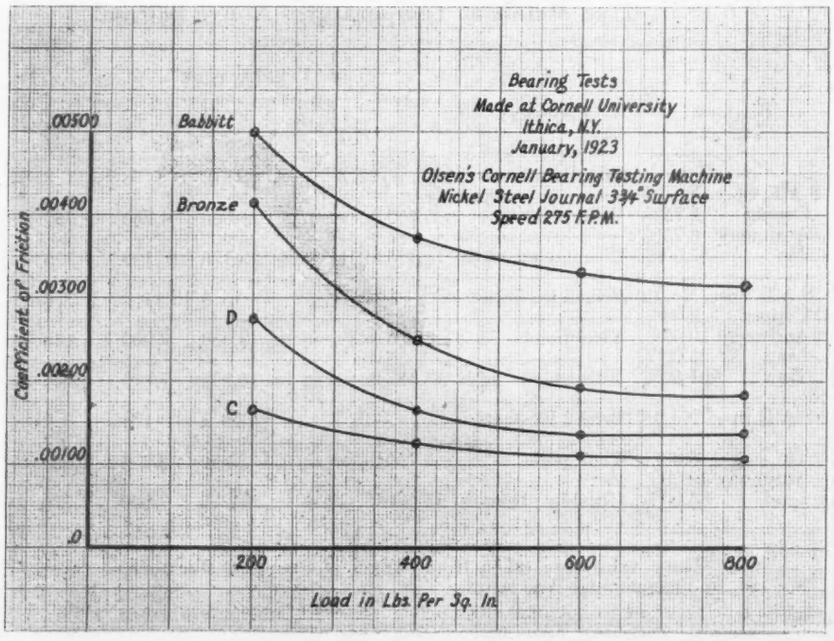
SnSb. The copper crystallizes out in the hooks and spines of composition Cu_3 Sn. The size of these crystals depends on the rate of cooling and it has been found that the metal with the rapidly-cooled, smaller crystals gives a superior bearing. That is one great advantage of die-cast babbitt bearings. The lead-base bearing metals (often incorrectly called babbitts) develop a similar structure.

It is seen, therefore, that the white bearing metals are composed of hard crystals imbedded in a soft matrix. The hard crystals carry the load and resist the wear, while the soft matrix has a fairly low co-efficient of friction and is plastic enough to easily adjust itself to the shaft. However, the effect of temperature on the white metals is disastrous, as is shown in the table. In fact the white bearing metals will usually melt at some temperature between 350 deg. F. and 500 deg. F.

Because of their superior strength, the bronzes are very largely used for bearings where the loads are heavy. They are not plastic and will not adjust themselves to the shaft. They are hard enough to resist wear, but at the same time this hardness is often ruinous to the shaft, particularly when the bearing is overheated. Cut and scored journals are often found when bronze bearings are used. The bearing bronzes consist of a copper base with varying amounts of tin, zinc and lead, and sometimes a little phosphorus, manganese, or aluminum. Strictly speaking they are not bearing metals, but are metals used for bearings simply because they are strong enough to do the work.

Fig. 2—Co-efficient of friction of tin-base babbitt, commercial bronze and two grades of copper-lead bearing metal.

The bearings were all tested on the same machine. The babbitt contained 84 per cent of tin, 7 per cent of copper and 9 per cent of antimony. The bronze contained 86 per cent of copper, 9 per cent of tin, 3 per cent of zinc and 2 per cent of lead. Curve *C* represents a copper-lead bearing metal containing 65 per cent of copper and 35 per cent of lead. *D* represents a similar metal containing 80 per cent of copper and 20 per cent of lead.



The third type of bearing metal is the result of the attempts to improve the bearing qualities of the bronzes by increasing the lead content, with the production of a copper-lead bearing metal. Some of the bronzes contain 10 per cent or even 15 per cent of lead, but it has been found commercially impracticable to add more than 15 per cent of lead because of liquation and segregation. A special process has recently been developed, however, for producing a copper-lead metal with the lead content as high as 60 per cent with 40 per cent of copper. The structure of such a metal is shown in the lower part of Fig. 1.

The copper-lead bearing metal developed by this process may contain from 20 per cent to 60 per cent of lead. The strength and hardness decrease as the lead increases. A consideration of the microstructure will show why this is so. As the molten mixture solidifies, the copper crystallizes out first in substantially pure form, and gives the dendritic, or tree-like crystals shown in Fig. 1. The lead eutectic remains molten long after the copper skeleton has solidified, and when it does freeze it fills in the interstices and cushions the copper. Thus the bearing consists of a skeleton or network of copper cushioned by lead. The strength of the alloy is simply the strength of the copper skeleton and, of course, it is not so strong as bronze. From 60 per cent to 80 per cent of copper, however, gives a bearing of higher strength than the same bearing in white metal. It is also possible to strengthen the copper to a certain degree by the addition of a small amount of tin or some other metal.

From a bearing standpoint the copper-lead metal combines the advantage of both bronzes and white metals. The copper skeleton can be made hard enough and strong enough to carry the load and resist the wear. The lead cushion makes it plastic enough to conform itself to the shaft, and at the same time cuts the amount of friction because of the lower co-efficient of friction of lead. A comparative study of the friction of four bearings is shown in Fig. 2. The bearings were all tested on the same machine. The babbitt is genuine, containing 84 per cent of tin, 7 per cent of copper, and 9 per cent of antimony. The bronze is a commercial bearing bronze containing about 9 per cent of tin, 2 per cent of lead, 3 per cent of zinc, and the balance copper. Curve (*C*) is that of a metal containing 65 per cent of copper and 35 per cent of lead; (*D*) contains 80 per cent of copper and 20 per cent of lead. The curve shows the superiority of the copper-lead metal over both bronze and babbitt. The copper-lead metal will also stand up under high temperatures, because of the high melting point. Copper-lead bearings have been run dry until the shaft was red hot, a temperature of 1,300 deg. F., without harm to either the shaft or the bearing.

D. E. Batesole, Asst. Engineer Manager, The Norma Company of America, New York, N. Y.: The articles which have appeared in the past few issues of INDUSTRIAL ENGINEER are indeed very interesting and should be of considerable help to everyone connected with the maintenance of plant equipment. Those particular portions of each article which deal with practical experiences in eliminating bearing troubles should be carefully noted by all engi-

neers, as similar troubles are likely to arise at any time. Concerning the matter of roller bearings as applied to electric motors, cranes and other plant machinery, we would offer the following ten important points to be looked after in order to obtain the most satisfactory results.

(1) The question of bearing selection should be given careful consideration. This applies both to the type of bearing as well as the size which should be used for a given application. The type of bearing to be used will depend upon a number of factors, such as (*a*) kind of service, whether load will be constant, variable or intermittent; (*b*) speed condition, that is, high or low speed, constant or variable; (*c*) character of load, whether it is all radial load or all thrust load, or part radial and part thrust and what are the relative proportions of each; (*d*) unusual conditions of operation, such as high temperatures, presence of unusual quantities of dust or impurities surrounding the bearings, and so forth. All of the above factors will enter into the selection of the proper type of bearing.

(2) The size of bearing will depend also to a certain degree upon the considerations mentioned above. Furthermore, the size will depend upon (*a*) the space limitations; (*b*) the diameter of the shaft under the bearings as well as the shaft extension diameter; (*c*) upon whether or not a bushing is to be used between the bearing and the shaft. When the loads to be carried are known and the space limitations are determined, it should be quite easy to select the weight of bearing to be used, that is, whether of light, medium or heavy series.

(3) Before considering the mounting and maintenance of the roller bearing, it is well to mention some important points in connection with the handling and cleaning of the bearing. Bearings are usually shipped by the manufacturer covered with some rust-resisting compound. In most cases this material will serve as a lubricant, but it is desirable to remove this covering and use a properly selected grease or oil for lubrication after the bearing is assembled. As a rule this slushing material can be removed by immersing the bearing for a time in kerosene. In many plants it is customary to keep the bearings, after they are cleaned, submerged in a covered can of kerosene until ready for use. This insures that the bearings will not become rusted before assembly. Do not under any circumstances allow bearings to lie about uncovered where they are likely to accumulate chips and dirt.

(4) In cleaning the bearings, an air blast is sometimes used. If this is done, care should be taken to see that this air does not contain excessive moisture or dirt. In many cases chips are blown into the bearings, and are very difficult to remove.

(5) Coming now to the matter of bearing mounting and the fits which should be used in this work, it must be remembered that a roller bearing is made up to exceedingly close internal tolerances and should, therefore, be mounted so that the internal clearance is maintained. In other words, excessive pressures should not be used either in forcing the inner rings on the shafts or the outer rings into their housings. In either case the internal clearance of the bearing may be so reduced, or the rings so distorted, that excessive heating will take place or in severe cases the bearing may not turn at all. The fit to be used will, of course, depend upon the size of the bearing as well as upon the particular operating conditions to be taken care of. In general, the manufacturers of roller bearings furnish information as to the tolerances of their bearings and the recommended fit allowances and it is advisable to follow closely their instructions to obtain satisfactory results.

(6) The rings of the roller bearing should be mounted so that the raceways are parallel. If it is impossible to insure that the inner and outer raceway will be parallel at all times a roller bearing of the self-aligning type should be used, as illustrated in Fig. 1. Otherwise, there is danger of the ends of the rollers being broken off due to the high pressure at their extremities. In general the bearing inner ring should be pressed firmly home against a shoulder on the shaft or against a bushing so that the ring is definitely located.

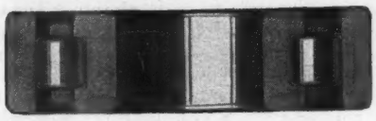


Fig. 2—This roller bearing is of the separable type.

The outer ring may be firmly fixed in the housing, as the rollers are free to move laterally across the face of the outer raceway, to compensate for expansion.

(7) Where there are excessive shock loads to be taken care of, there is a possibility of a peening action being set up between the outer ring of the roller bearing and its housing. For that reason no appreciable looseness should be permitted between outer ring and housing so that there is no chance for this peening effect to develop. A bearing of the separable type such as shown in Fig. 2 has the advantage that the outer ring may be separately and firmly mounted in the housing, irrespective of the inner ring and rollers, and in this way there is less chance for looseness to be present.

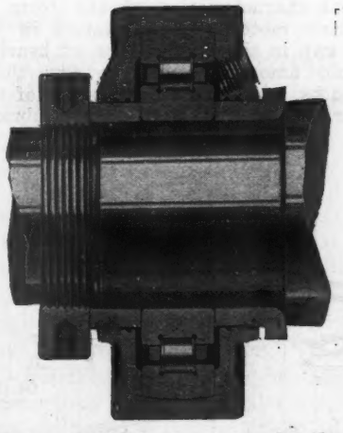


Fig. 1—Self-aligning type of roller bearing.

It is recommended that this type of bearing be used where difficulty is encountered in making or keeping the inner and outer raceways parallel.

(8) Expansion of the shaft under increased temperature should also be taken care of. If the distance between bearings is large and the change in temperature likely to be great, sufficient provision should be made for the shaft to expand without cramping the rollers on their ends. When roller bearings of the self-contained type are used one is usually fixed, while the other is free to move laterally. Roller bearings of the separable type, as in Fig. 2, take care of expansion in the bearings themselves as the rollers are free to move across the faces of the outer raceways.

(9) The kind of lubricant to be used will depend upon operating conditions. Whether grease or oil is used, it should be carefully selected so that nothing is present in it which will affect the life of the bearings. All lubricants should be entirely free from acid or alkali and should not contain foreign matter of any kind. Suitable means should be provided to see that the lubricant is kept in the bearing housing and also that dirt or grit is not allowed to enter under any conditions.

(10) The care of the roller bearing should be in competent hands. In other words, it is desirable that some person or persons be given the responsibility of looking after them. The bearings should be lubricated at regular intervals, the length of time between oilings depending again upon operating conditions. A little experimentation along this line will determine the best practice for each individual case. It is advisable to keep a log or record of each mounting and when it is lubricated, or else have a certain day of each week or month set as the day on which the bearings are to receive additional lubrication.

It may appear from the above that the proper mounting and upkeep of a roller bearing is quite difficult but such is not the case. We have only endeavored to point out the best practice based upon our experience with bearings of this type on a great variety of applications. By following a few fundamental rules of care and mounting it will be found that a well-made roller bearing will give satisfactory service over many years under the most severe operating conditions.

T. V. Buckwalter, Chief Engineer in Bearing Design and Installation, The Timken Roller Bearing Co., Canton, Ohio: The general subject, the substitution of the rolling bearing for the sliding bearing, in electric motors, is receiving constantly increasing attention. There is apparently some thought in certain quarters that much of this attention is due to the effort of bearing manufacturers to introduce their product into motors but this line of reasoning is not strictly true as those most interested in the subject are some of the large users of electric motors.

Studies made of the subject by this company, particularly among the large users of electric motors, indicate that these users attribute 70 to 80 per cent of their motor troubles to bearing failure. It must be at once granted that the actual replacement cost of bearings incidental to motor failures does not represent this percentage, but failures such as burn-outs incidental to the rotor riding on the stator, and which

are incidental to the bearing failure, should be charged to the bearings and most of the maintenance men are now taking this viewpoint. Let us look into the advantages following the application of taper-roller bearings to electric motors: We will first take up the matter of mounting and this can best be described by referring to the illustration which shows the application of taper-roller bearings to a typical induction motor, the section of the motor being taken from a layout having a rating of 100 hp. at 1,200 r.p.m. It will be observed that a pair of taper-roller bearings will take any combination of thrust or radial loads that can be imposed on the bearing in ordinary motor service, and this combination of loads might be due to a variety of causes such as misalignment on belt, shaft or gear drive, inclination of the motor from level, or use of bevel gearing on first reduction.

The bearing consists essentially of two parts: namely, the cone and roller assembly which is combined as one unit, and the cup. The distinct feature of a taper-roller mounting is that the bearings are invariably mounted in pairs and while, in the case of the electric motor, the weight of the motor is divided between the two bearings, thrust reactions, on the other hand, are taken on one or the other of the bearings, depending on the direction of the thrust.

The cones can be mounted on the armature shaft direct with a light press fit and require no clamping nuts or other accessory apparatus necessary with annular types of bearings. The cups are mounted directly in the bell housing and each cup is located endwise in one direction only, clamping rings and abutments being entirely eliminated. This provides for through reaming in machine work and maximum economy in machining operations. Housings can also be made symmetrical and much of the core work necessary with the plain bearing is eliminated entirely.

Lubrication can be accomplished by either suitable grease or a medium motor oil. Oil lubrication requires that the oil hole be located below the armature shaft to avoid leakage inward to the winding, while grease lubrication could best be provided with an ordinary grease gun, injecting the grease directly into the bearing housing but without pressure. One of the drawbacks of grease lubrication is that the bearing housing can be filled too full, leading to leakage of the grease past the armature shaft where it can be blown onto the windings. A proper charge of either oil or grease is about one-third the capacity of the housing.

The particular advantage of taper-roller bearing mounting is the economy of space on both diameter and length. The projection of the bearing housing on either end of the motor is greatly reduced, but on the other hand the symmetrical mounting provides for uniform and maximum possible ventilation.

A decided advantage of the taper-roller type of bearing is that it is adjustable for wear. Considering the long-continued service, relatively high speed, and in some cases, a high load factor, this is an important consideration. It must not be assumed that because a bearing is adjustable for wear that it will wear any faster than a non-adjustable bearing. The amount of wear in a bearing of the rolling type depends, first, on the composition and heat-treatment of the steel, the amount of rolling surface, and the reduction in unit pressure on the rolling elements and, second, cleanliness of assembly. These characteristics are all obtained in their maximum with the taper-roller bearing and are given preference. The wear is less with this type than with other forms of bearings.

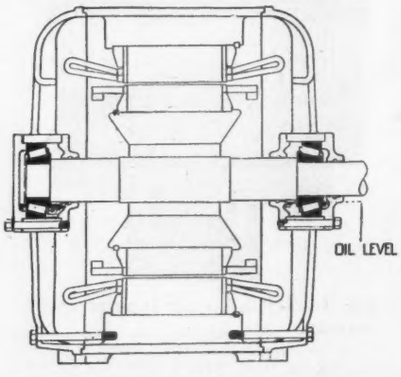
The great advantage of this form of bearing is that with a simple adjustment, by removing the shims in the motor illustrated, contact and alignment can be renewed whereas, on the non-adjustable bearing of either plain or rolling type, a complete replacement is necessary.

The second great advantage of the adjustable form of bearing is that extremely close work on the fitting of the bearings is unnecessary. It is granted that a press fit of the cone or inner race is essential on heavy motor service and on the races of the non-adjustable bearing this press fit must be very carefully handled, as otherwise an expansion of the inner race occurs. The taper bearing will function satisfactorily, regardless of whether the cone is light press fit or heavy press fit. The heavy press fit of course results in more expansion of the cone but this is automatically taken care of in making the adjustment.

The question of noise in the bearing, which is more or less present in any rolling form of bearing, can be very nicely controlled with the adjustable bearing by means of the adjustment whereas, in a non-adjustable bearing this running freedom must be nicely controlled in the manufacture and also in the mounting of the bearing.

Economy in lubrication is an important advantage following the use of the rolling type of bearing. There are instances on record of electric motors running 22 hours per day for periods of over one year without attention to lubrication.

The maintenance of the air gap without variation should improve the electrical characteristics of any form of electric motor. The variation in the air gap in the rolling type of bearing would amount to only a few thousandths, measured on the radius of the bearing and this, with proper lubrication, should be obtained only after years of service and which can be corrected by a very simple adjustment.



Installation of taper-roller bearings in large induction motor.

The relative cost of electric motors equipped with the rolling type as compared with sliding types of bearings, has not been worked out to a finality, but the indications thus far are that with the use of taper-roller bearings the difference in cost of motors will not be a material factor, the indications being that there will be no appreciable difference in cost, particularly after consideration is given to the increased cost of the bearing as measured against the decreased cost on other parts of the motor such as the armature shaft, bell housing, and simplified foundry work.

The illustration of the induction motor might be considered as typical of ordinary motor practice, and it is recognized that special forms of motors such as mill motors of the split type, railway and mining motors, must have special consideration given to the matter of bearing selection and mounting.

H. R. Reynolds, Chief Engineer, The Fafnir Bearing Co., New Britain, Conn.: In considering ball bearings for electric motors it is not our intention to criticise or condemn other types of bearings; rather we hope to bring out certain points which are factors of ball bearing service. In general ball bearings give superior service in any application. The conditions don't always require such service. However, the electric motor does.

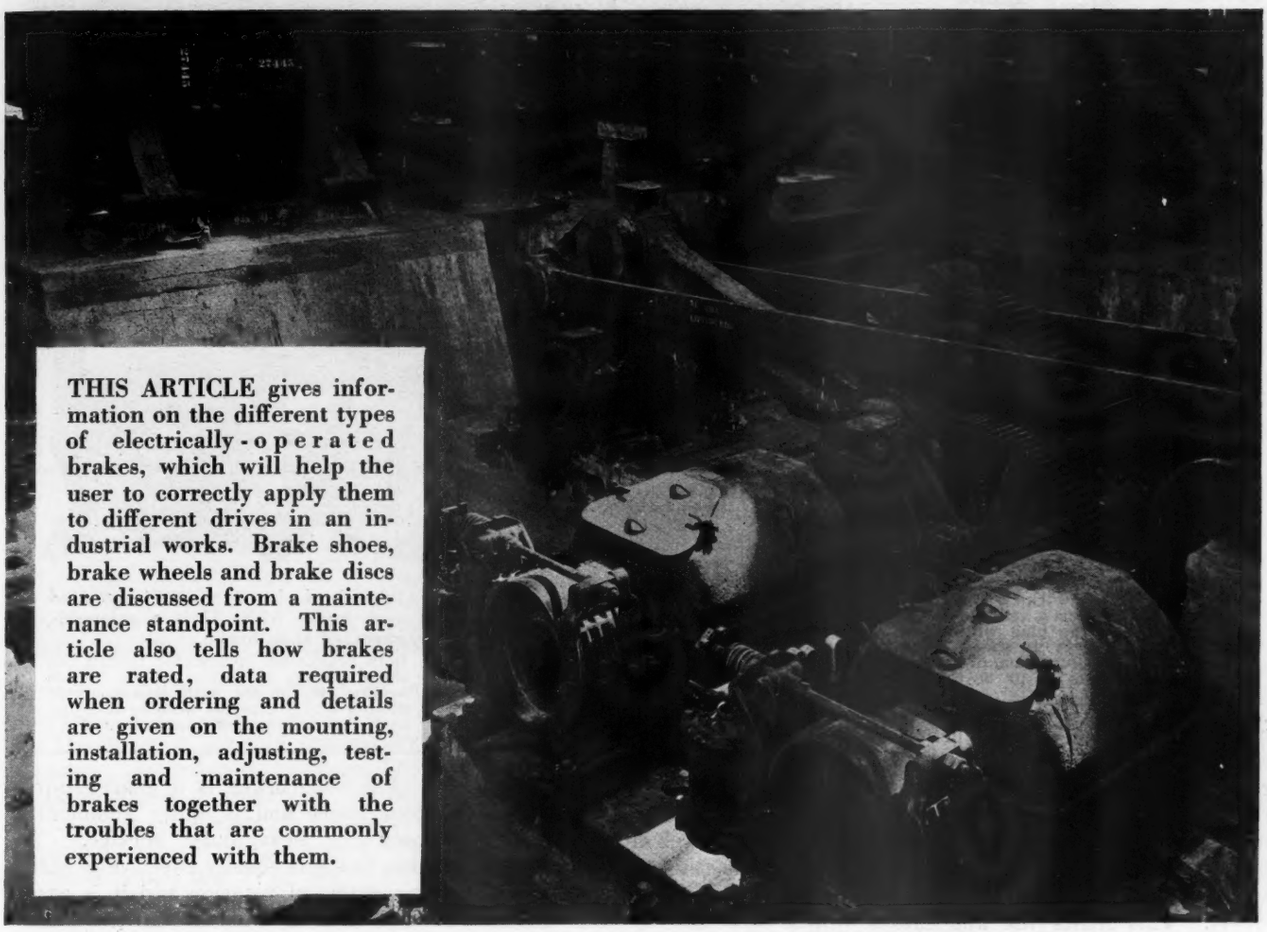
Unfortunately, in the past the ball bearing engineer has been largely influenced by automotive design and ball bearings for industrial use have been recommended from data on hand which was not based on industrial requirements. The resultant ball bearing service was quite frequently unsatisfactory; hence early experimenters were often discouraged.

Several ball bearing manufacturers are today in a position to make very intelligent ball bearing recommendations for ball bearing machine applications, having a trained group of engineers specializing in the different fields. The electric motor has received a large share of this attention, so that today ball bearing recommendations for electric motors are made from a sound knowledge of conditions surrounding such service.

Properly selected and applied, there is no bearing made that gives as efficient, carefree service as the ball bearing. If they could be purchased and applied for the same price as other bearings there is no question regarding their universal use. Here it should be stated that quite often, once properly equipped, the manufacturer is delighted to find how closely his costs will approach each other.

Especially desirable characteristics of ball bearings for electric motor service are the following:

(1) There is no wear on the rotor shaft. (2) They are grease lubricated instead of oiled, thus assuring absence of shorts from oil-soaked windings. (3) They take care of both radial and thrust loads, thus doing away with troublesome thrust collars. (4) They insure permanent alignment, as replacement of a worn bearing promptly restores original conditions. (5) In general it is easier and much quicker to replace ball bearings than those of the sleeve type, (*Continued on page 304*)



THIS ARTICLE gives information on the different types of electrically-operated brakes, which will help the user to correctly apply them to different drives in an industrial works. Brake shoes, brake wheels and brake discs are discussed from a maintenance standpoint. This article also tells how brakes are rated, data required when ordering and details are given on the mounting, installation, adjusting, testing and maintenance of brakes together with the troubles that are commonly experienced with them.

Fig. 1—These brakes are on the motors driving the tilting mechanism of a bar mill in a large steel plant.
The two motors are geared direct to the same mechanism, hence both brakes retard, stop and hold the mechanism.

Details of Service and Construction of

Brakes Used to Retard Or Hold Rotating Parts

of Cranes, Hoists, Elevators, Turntables, Lineshafting and the Like to Prevent Overtravel, to Stop at Definite Points, Hold Loads and Make Emergency Stops

By ARTHUR J. WHITCOMB
Associate Editor, Industrial Engineer

A BRAKE is a device for retarding or stopping rotary motion by friction. An electric brake is one set by mechanical means and released electrically. Some brakes are set by gravity through the action of a weight attached to a lever arm; others are set by springs. Release is accomplished by a magnet or solenoid, although a small motor is sometimes used. The function of an electric brake may be to retard and stop a motor or machine, to hold a machine at rest against some force or to perform both of the above duties.

Electric brakes may be classified according to mechanical form or as to electrical characteristics. Classified as to mechanical form, there are band brakes, disc brakes and shoe or post-type brakes. Divided according to electrical characteristics there are shunt-wound and series-wound types, alternating-current and direct-current types, and lastly solenoid-operated, magnet-operated and motor-operated types.

Brakes Classified According to Mechanical Form

The band brake is a very familiar form. It consists of a band which encircles a brake wheel. The band is lined on the inside with woven friction material, wood blocks, composition blocks, or other friction material. Usually one end of the band is anchored; the other end is pulled tight around the brake wheel by a weight or spring. A solenoid compresses the spring or lifts the weight as the case may be. Fig. 4 on page 272 shows a band-type brake and in Fig. 2 is a cross section of the solenoid that operates it.

The band brake has a large braking area, for nearly the entire face of the brake wheel is effective for

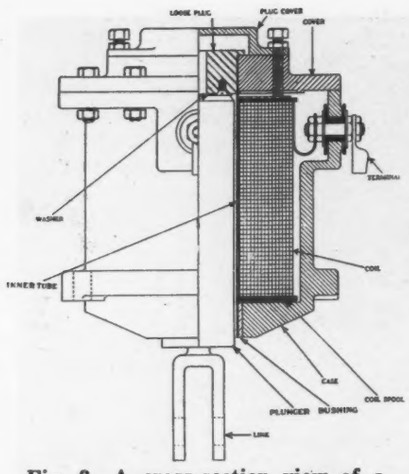


Fig. 2—A cross-section view of a solenoid used for operating band brakes.

This solenoid has a loose plug which provides a strong pull and a fixed position for the plunger when sealed. In operation the plunger engages the plug at the end of its working stroke; it continues to rise for a fraction of an inch and carries the plug with it until the stored energy is spent. Both the plunger and plug then drop back until the plug rests on its seat.

braking. The dead-end or anchored-end type of band brake exerts more retarding torque in one direction than in the other. The braking is most effective when the brake wheel is rotating in the direction which tends to wrap the band around the wheel. This limits the application of the dead-end type of band brake almost entirely to hoists, where braking is needed in only one direction.

The band brake is usually applied to the intermediate shaft of a crane hoist, where a holding brake is desired. A brake is put on this shaft to give greater safety. In case the armature-shaft brake should fail or if the motor pinion or motor shaft should break, the intermediate-shaft brake will hold the load. Quick-acting brakes on both the armature shaft and intermediate shaft will cause backlash and hammer blows to be given to the gearing. Since the band brake is slow acting, due to its long-stroke solenoid and is more effective in one direction than the other, it makes a very suitable brake for the intermediate shaft of a hoist. The quick-acting armature shaft brake will retard and stop the load while the band brake will help to or actually hold it if necessary.

The disc-type brake consists of a series of rotating plates alternating with a series of stationary plates. The rotating plates which are lined on both sides with a friction lining, are loosely keyed to a hub so that they are free to move laterally. The hub is mounted on or connected to the motor shaft. A compression spring is arranged to press the plates together and thus set the brake. The armature plate of a magnet compresses the spring and thus releases the brake. A cross section of this type of brake is shown in II of Fig. 6 and an application of it to the screw-down on the main rolls of a blooming mill is illustrated in Fig. 5 on page 273. In another form of the disc brake only one rotating disc is used which is clamped between the magnet armature and a stationary plate fastened firmly to the brake frame.

The disc-type brake is of relatively light weight, has a compact construction requiring little room perpendicular to the shaft and is quick acting. It gives equal braking torque in either direction of rotation. Due to the light weight of its moving parts it has small inertia. The disc brake is a general service brake.

The shoe brake consists of a brake wheel and a pair of shoes lined with friction material, operated through a mechanism by either a magnet or a solenoid. The shoes are made to clamp the wheel either by weights or springs acting through levers. In Fig. 3 on this page are shown brakes which are set by the action of springs. In Fig. 7 is shown a brake set by gravity acting through a weight. The shoe brake is rugged and accessible. It is arranged to permit easy removal of the armature.

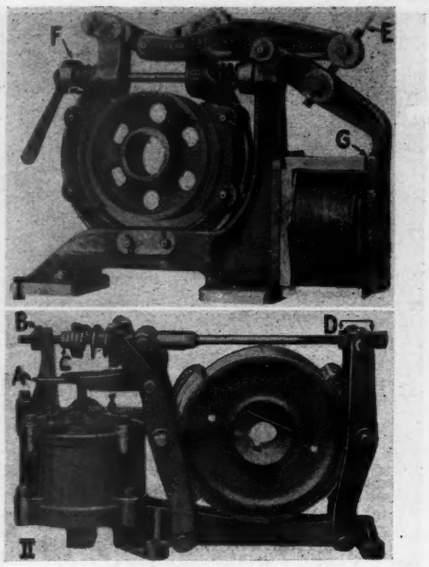


Fig. 3—I is a magnet-operated shoe brake while II is a solenoid-operated shoe brake.

Both brakes use springs for forcing the shoes against the brake wheel. These brakes are for use with direct-current motors and are series wound, although they can be supplied shunt wound.

The shoe brake is a general-purpose brake and is quite commonly used for heavy-duty service. A shoe brake is equally effective in both directions of rotation and it is easy to keep it adjusted so that the shoes do not drag.

Brakes Classified According to Electrical Characteristics

Classified according to electrical characteristics, brakes are designed for either direct-current or alternating-current service; solenoid-, magnet- or motor-operated; or shunt or series wound.

Direct-current brakes are made in the solenoid- and magnet-operated

Fig. 4—Series-wound, solenoid-operated band brake operating on a skip hoist.

The mechanism at the top of the band pulls the top of the band clear of the wheel when the solenoid releases the brake. The brake wheel is on a shaft that is coupled to the armature shaft.

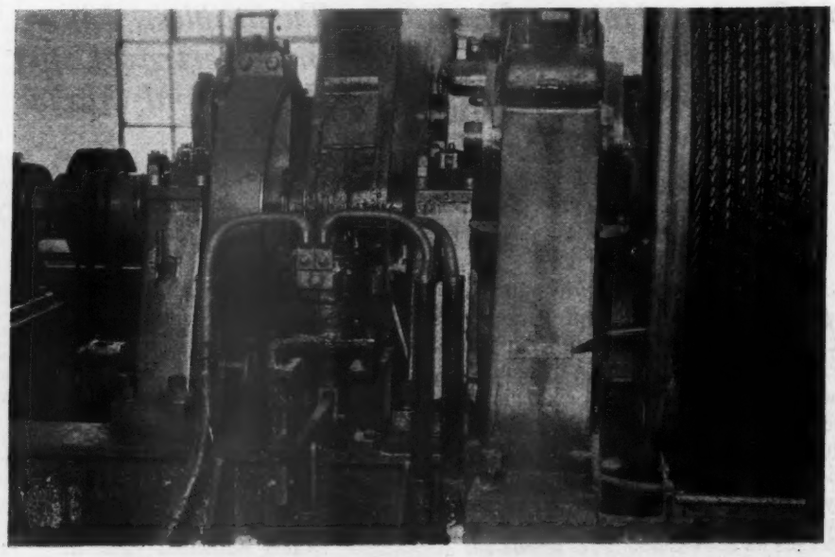


Fig. 5—A disc-type brake operated on the screw-down of a reversing blooming mill.
On an application of this kind, a brake is subjected to severe service and heavy overloads.

types. A solenoid-operated type is shown in Fig. 7 and in II of Fig. 3. In the latter a solenoid compresses a spring; this releases the brake. The braking force is controlled by the adjustment of this spring. Magnet-operated, direct-current brakes are illustrated in I and II of Fig. 6 and in Figs. 5 and 8. In these types the magnet takes the place of the solenoid and performs the same function.

Alternating-current brakes are made in solenoid- and motor-operated types. In Fig. 7. and Fig. 10 are shown solenoid-operated, alternating-current brakes. In II of Fig. 9 is illustrated a magnet-operated, alternating-current brake. This type has a laminated armature and core for the magnet. A motor-operated, alternating-current brake is shown in I of Fig. 9 and in III of Fig. 6. This brake is set by a spring and released by what is equivalent to a high-torque, squirrel-cage, induction motor driving through a pinion and toothed sector to which the brake-operating lever is attached.

Solenoid- and magnet-operated, direct-current brakes are made with the operating coils either shunt wound or series wound. Most direct-current brakes are series wound for the obvious reason that a coil thus connected is automatically de-energized and the brake set when the current is off. Also there is the absolute assurance that when the brake is released the motor has current to hold the load. The series-wound brake acts more quickly than the shunt-wound brake. In the case of a crane, an extra trolley bar and collector would be required if a shunt brake were used. Due to the fewer turns and relatively large wire of the series coil, it is more rugged than the shunt coil. However, shunt brakes have characteristics that make them almost indispensable when operated under the following conditions:

(1) Where a drift or coasting point is desired when the power is cut off from the motor on such applications as lift bridges, trolley motion of ore bridges, and the like.

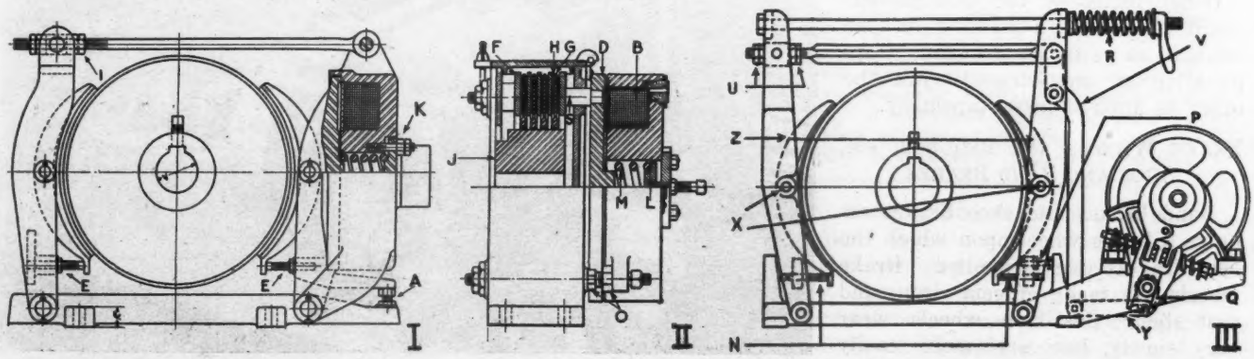
(2) Where the current passes through a very low value or through zero and flows in the opposite direction at some time during the cycle as is the case in elevator and mine-hoist service. On a crane hoist, the brake is usually connected in series with the series field in lowering. If a high lowering speed is required, it is often necessary to weaken the series field to a point where the series brake will not hold open. Shunt brakes are, therefore, frequently used on the hoists of coal and ore bridges, skull crackers and similar service.

(3) In some cases shunt brakes are required where resistance is used in shunt with the armature to obtain slow-down, as on skip hoists, bell hoists and car dumpers.

The advantage of the series brake lies in its simplicity of action while the strong point of the shunt brake is its flexibility of application.

All alternating-current brakes are made for shunt operation. For three-phase service, solenoid brakes are often provided with three coils, one for each phase. The magnet-operated brake is operated single phase. The motor-operated brakes are made for operation on two- and three-phase circuits only.

Fig. 6—Structural details of three types of brakes.
In I is shown a direct-current, magnet-operated, shoe-type brake. This is the same type of brake shown in Fig. 8. II is a disc-type brake. It is released by a magnet *B* and *D* and is set by the spring *M* acting through *D* and *S* on the stationary plates *F* and the rotating plates *G*. The rotating plates *G* are loosely keyed to the hub *J* which is keyed to the shaft on which the braking is to be applied. *H* is the friction lining on the discs *G*. III is a motor-operated alternating-current brake. The motor acts through the toothed sector to the crank *Q*, through the link *Y* and lever *V*, and through the brake arms to release the shoes *Z*. The brake is set by means of the spring *R*.



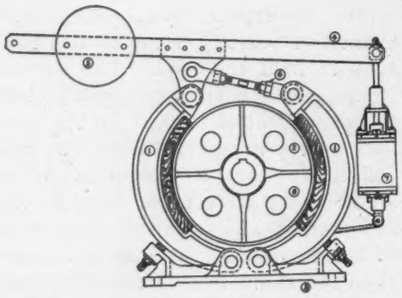


Fig. 7—Another type of solenoid-operated shoe brake.
This brake is set by a weight instead of a spring. Although this brake can be used on direct-current service it is mainly used on an alternating-current supply. For a three-phase supply, three coils are used; one coil is connected across each phase.

Special Type of Brake Giving a Graduated Retarding Torque

Some special applications require a brake which gives a graduated braking effort. A multiple-solenoid brake has been developed for this requirement. It is really two brakes in one, one solenoid being arranged to release the greater part of the total braking torque and the other solenoid to release the lesser part of the total torque. When used with induction motors, one solenoid of this brake is connected across the line and is energized only while hoisting. At standstill or when lowering, except on regenerative braking points, this solenoid is de-energized. The second solenoid of the brake is connected across one phase of the wound rotor of the induction motor. When both solenoids are de-energized, as at standstill, full braking torque is developed. When hoisting, both solenoids work together to release the brake. In lowering the second solenoid varies the braking torque according to the motor speed. The higher the lowering speed, the less motor slip, and consequently the lower the voltage applied to the second solenoid and hence the greater the braking effort. This type of brake is illustrated at *A* in Fig. 10 on page 305.

Other forms of the multiple-solenoid brake use a dashpot on one solenoid so as to secure gradual application of one solenoid while the other is applied instantaneously.

Brake Wheels are Required for Shoe and Band Brakes

Band brakes and shoe brakes require a brake wheel upon which the retarding torque is applied. Brake wheels are made of cast iron and cast steel. Cast-iron wheels wear very slowly, but are more easily broken than cast-steel wheels. Cast-steel wheels are probably in more common use. Cast-steel wheels are generally harder than ordinary steel as a balance is struck between hardness for wear and softness for machining. One manufacturer machines the brake wheels from cast steel and then subjects them to his own hardening treatment which converts the wearing surface to tool steel, glass hard. It is claimed that very long life is obtained with these wheels.

Brake wheel sizes vary. In diameter they vary from 7 in. to 30 in. according to rating. The width of the face or braking surface of the wheels varies from 2¾ in. to 8½ in. The safe permissible speeds for these wheels varies according to the diameter of the wheel. With the smallest-diameter wheels a speed of approximatly 2,500 r.p.m. is considered the maximum, while with the largest wheels a speed of about 670 r.p.m. is the highest safe speed. The inside of the face of the larger wheels is often ribbed so as to help radiate the heat generated during severe service. A ribbed wheel is shown in Fig. 8 and Fig. 10.

Brake wheels are furnished either with tapered bore or straight bore. The tapered bore is the more usual. The wheel with a tapered bore is keyed to the shaft and held in place by a nut screwed on the end of the shaft. The straight-bore wheel is pressed on the shaft and keyed.

In a shoe brake the retarding torque is developed by the pressure of the brake shoes on the brake wheel. The brake shoes are commonly made of cast iron and are fastened by pins to the lever arms through which the pressure is transmitted from the compressed spring or weight. The manner of fastening the shoes to the lever arms is shown in Fig. 3, in I and III of Fig. 6, in Fig. 7 and in Fig. 9. In some brakes the shoes are self-aligning and in others adjustments are made so as to align the shoe with the surface of the brake wheel.

The inside of the brake shoe is covered with a friction lining, usually made of woven asbestos. There are (*Continued on page 304*)

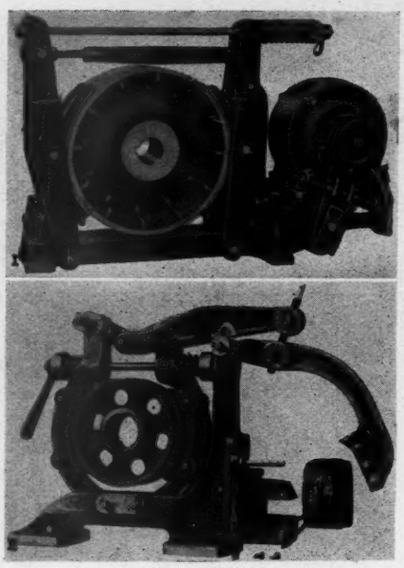
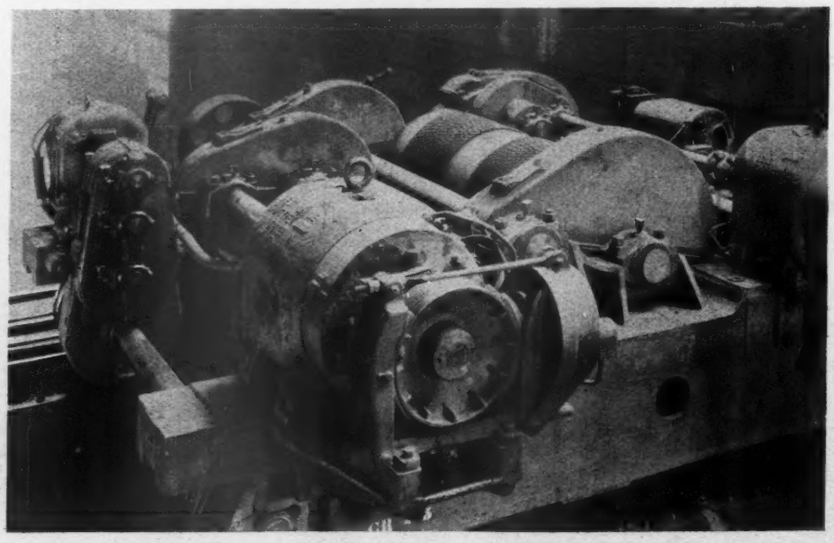


Fig. 9—Two types of brakes for use on alternating current.
I is a motor-operated shoe brake, while II is a magnet-operated shoe brake. In II, the coil has been removed so that the laminated structure of the core may be seen. Notice that the armature is also laminated.

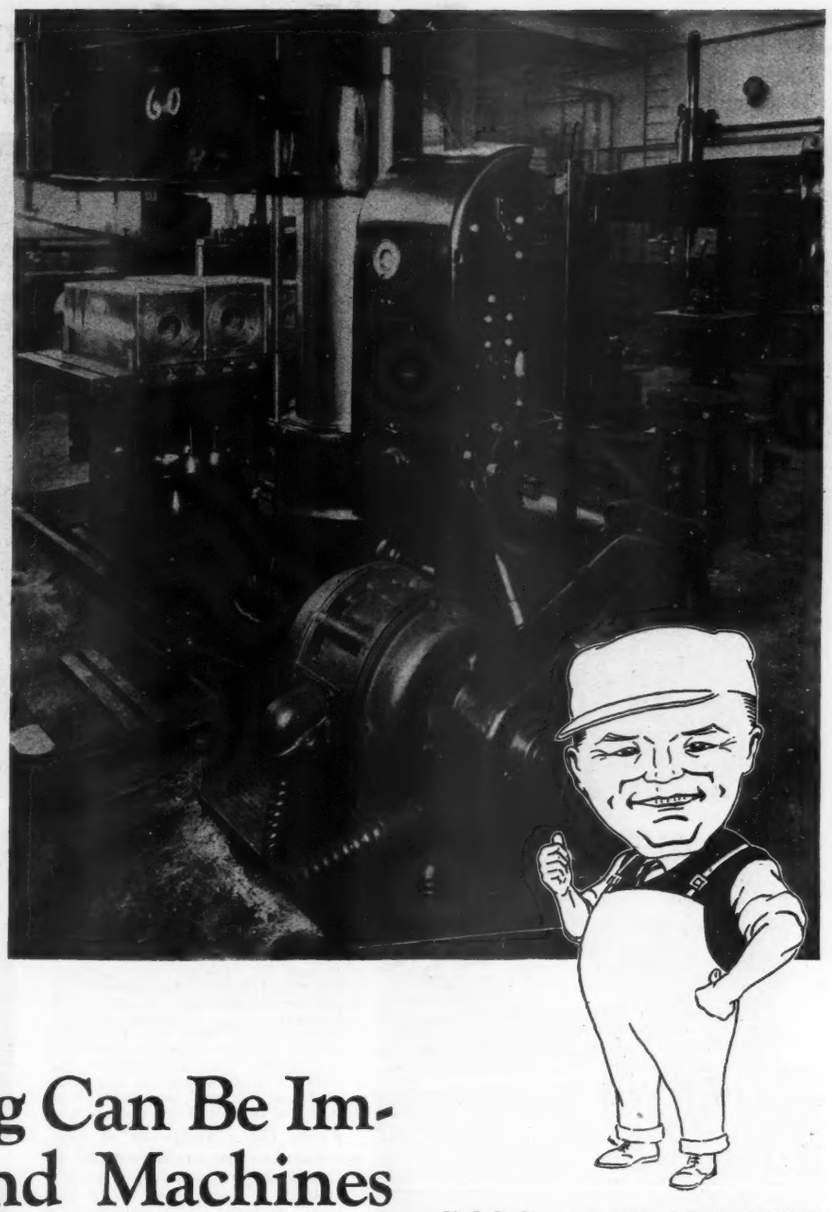
Fig. 8—A magnet-operated, shoe-type brake operating on the hoist motion of a crane.
Notice the ribbed brake wheel which aids in radiating the heat generated on the braking surface of the wheel.



THIS IS the second part of an article which started in the May issue. In the first part I spoke of wiring from the standpoints of safety and continuity of operation. In this article wiring is treated from the viewpoints of convenience of operation, ease of construction and cost. These two articles are illustrated with pictures of good and bad wiring jobs so that you can check up your own work and sort of make a mental examination of how good or how bad it may be.

Once in a while a young fellow gets the idea that his boss is an old fogey and particular far beyond any practical necessity. But after a few years of experience, when he gets in a boss's boots he forgets that at one time he did not know it all and sometimes bears down a little hard on his men when their work is not just up to the standard that he knows it might be.

Because I used to be one of those young fellows and later was a boss, I have tried in this article to point out the things that make a wiring job good and give the reasons therefor. If you are a boss pass this article around among your men. If you are not yet a boss, but expect some day to be one and want more information on any of the points discussed, just drop me a line and I'll try to give you what you want.



If I had to rate this job I would be forced to mark it about 99.99 per cent. The conduit with the power supply comes through the bedplate to a condulet located beneath the motor bearing and then through the conduit installed in the framework supporting the control, to a box on the rear of the compensator. The safety switch is located on the back of the framework and against the box, consequently the wiring between the switch and the compensator can be placed in this box. The leads from the compensator to the motor go through the same conduit to the condulet, beneath the motor bearing. From this point it is connected to the motor condulet by flexible metallic conduit. A minimum amount of wire and conduit were used on this job, yet the wiring is accessible and well protected.

Some Spots and Places

Where Wiring Can Be Improved Around Machines

With Do's and Don'ts That You May Know About Arranged to Save You Time When Breaking in New Men and Helping Them to Understand Why You May Be so Fussy About Doing a Good Job

Suggestions by

Practical Pete

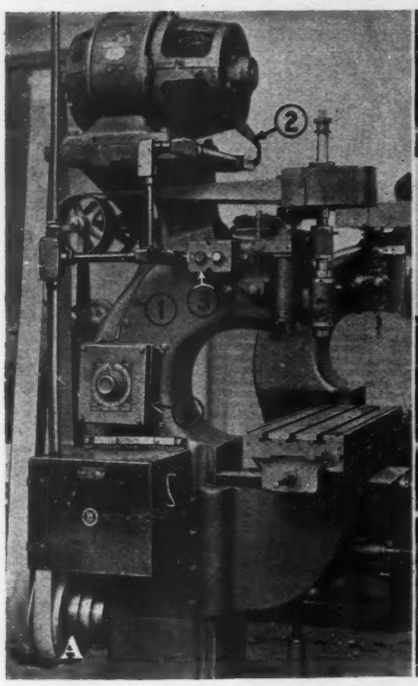
Part II

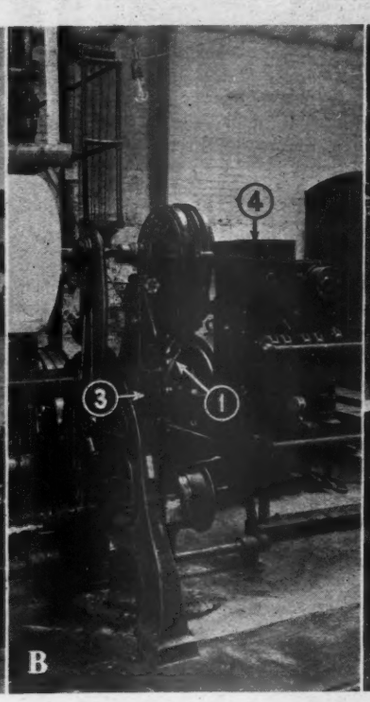
AFTER an installation has been laid out with respect to safety and continuity of operation, convenience should be considered. By this I mean the location of the various pieces of equipment so as to enable operation of the machine with the least effort on the part of the operator and also to readily enable a thorough inspection by the maintenance crew.

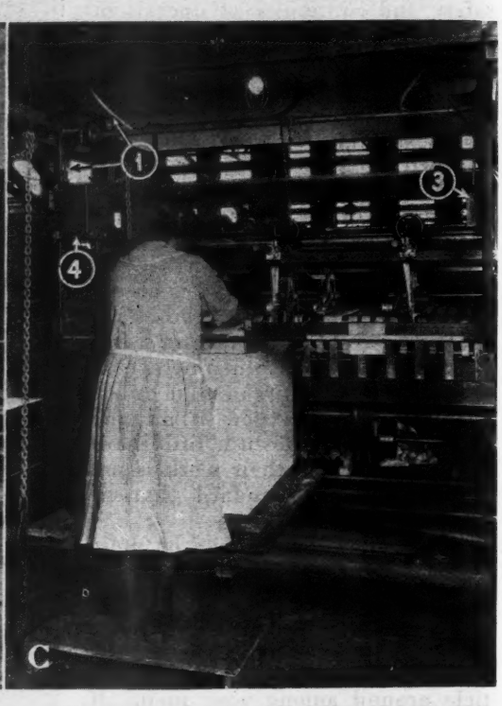
First let us consider the location of the master switch or start-stop button and the speed-regulating devices. If the machine is frequently started and stopped, the master switch or start-stop button should be placed near the operator's hand so that it will be unnecessary for him to change his position to control the machine. If the same operator controls several machines, the most frequently used master switches should be located at the nearest convenient point. For instance on a bucket-handling crane there are usually four drum controllers to be manipulated; the bucket-opening control, the bucket-closing (combi-

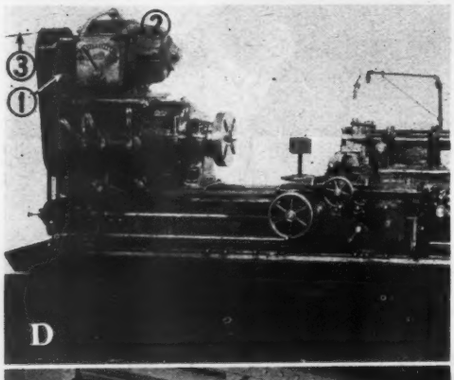
Here Are Eight Wiring Jobs

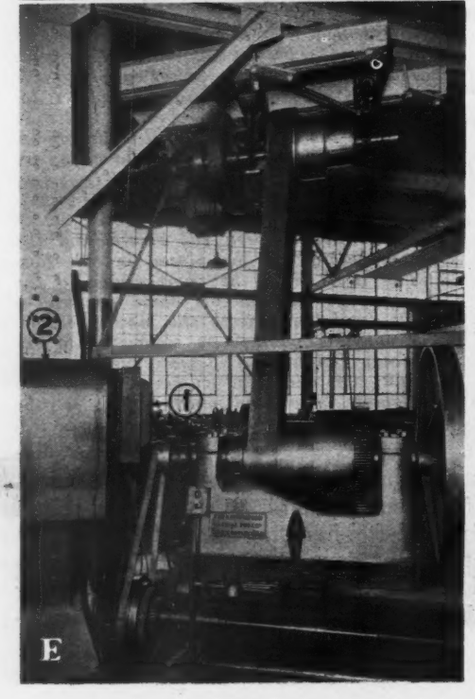
With Some Comments on the Good and Bad Features of Each











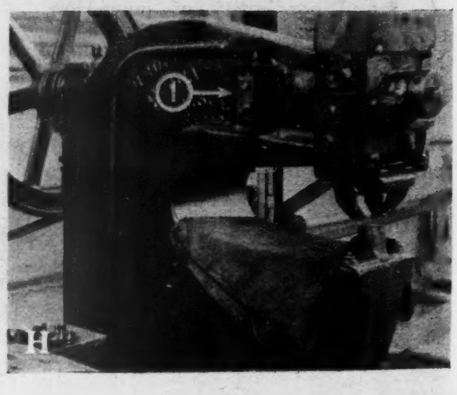
At (A) is shown an installation that is very good. There are, however, one or two points that you will say could be improved. For instance those field-rheostat leads (1) should be enclosed in the manner shown at (1) in illustrations *B* and *C*. I don't particularly like the looks of the wires leading into the motor at (2) in illustration *A*. Flexible conduit should have been run from the conduit at the push button up to the motor condulet. Notice the convenient location of the push buttons (3) and the field rheostat (4) in all three pictures.

From the standpoint of convenience the arrangement of motor and control in illustration *D* is good, but when you think of safety and reliability it doesn't rate so high. Contrast the open knife switch at (1) in *D* with the push button and safety switch at (1) in *E*; also compare the starters (2) in each picture from a safety standpoint. The wiring at (3) in illustration *D* lacks every semblance of a good job.

Do you like to see conduit on the floor as shown in (F)? How much better the job would look if the conduit did not have so many odd bends. The appearance of this job might have been improved in several ways. For instance, the conduit might have been buried in the floor or, by the use of condulets, the conduit could possibly be carried on the wall adjacent to the floor.

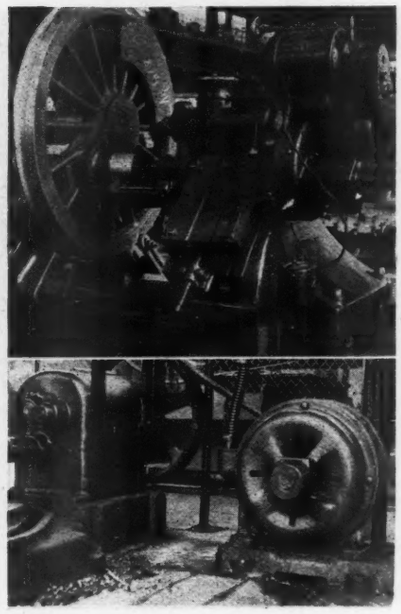
Here is a convenient location of a controller on a lathe as shown in illustration *G* at (1). This drum in conjunction with the automatic starting panel at (2), starts, stops, and reverses the lathe. The drum controller is operated from the apron by means of a spline shaft and chain. Note the enclosure of the panel at (2) and the flexible conduit at (3).

At (1) in illustration (H) is shown a very convenient lo- cation for the start-stop button of a motor-driven punch.



Here's a good job (at top), but it could be improved immensely if flexible conduit had been used instead of tape around the loose wires running from the motor to the controller.

I would have used flexible conduit because the motor is mounted on a part that is capable of being moved on the V-rails. The picture at the bottom illustrates the use of flexible conduit.



nation of these two hoists or lowers the bucket), the trolley control and the bridge control. Of these four, the bucket-opening and bucket-closing controls are used most often but the bucket-closing control receives the most use of all. On one good installation I know about, the bucket-closing control is located on the floor at a convenient height for the operator's right hand and the bucket-opening control is similarly located on the left side for the operator's left hand. The trolley control, which is used more than the bridge control, was located overhead with the handle hanging down convenient for the operator's right hand. The bridge control was similarly located at the operator's left hand. This arrangement caused the operator the minimum possible movement of his hands when changing from one control to another.

Sometimes the controllers for several machines are located in a row, the most used controller being directly in reach of the operator while the less frequently used controllers are reached by moving a little to one side.

In locating a controller it is often convenient to have the motion of the controller handle bear some relation to the movement of the machine. If the machine is a roll table or the trolley of a crane it would only be natural to move the handle forward and expect the machine to go forward. On a hoist it is customary to move the handle forward for lowering and pull it back to hoist. This is done because with the handle forward it is easier to look down to watch the hook while lowering.

I had something to say about the installation at the left in the April, 1922, issue, but it's so good that I want to take another shot at it here.

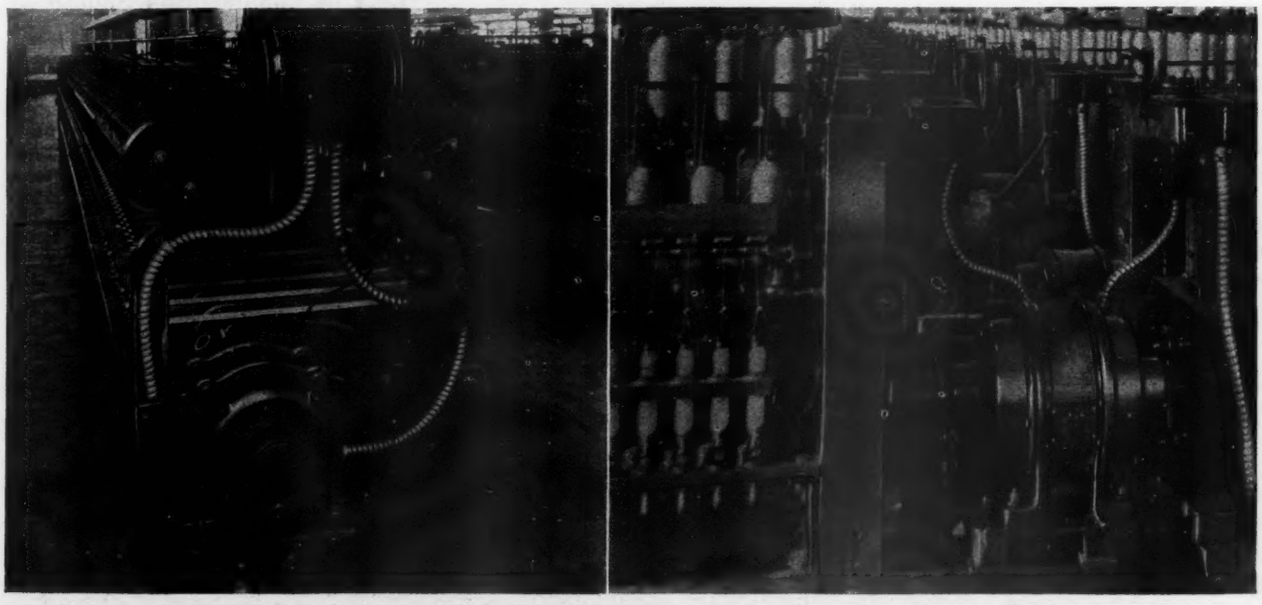
The engineers who laid this out and the contractor who put it in, make all their jobs look like this. The job at the right shows an adaptation of a similar layout in closer quarters. Note the convenience of starters, the good wiring and general safety of these installations. Here are good standards to compare your own work with.

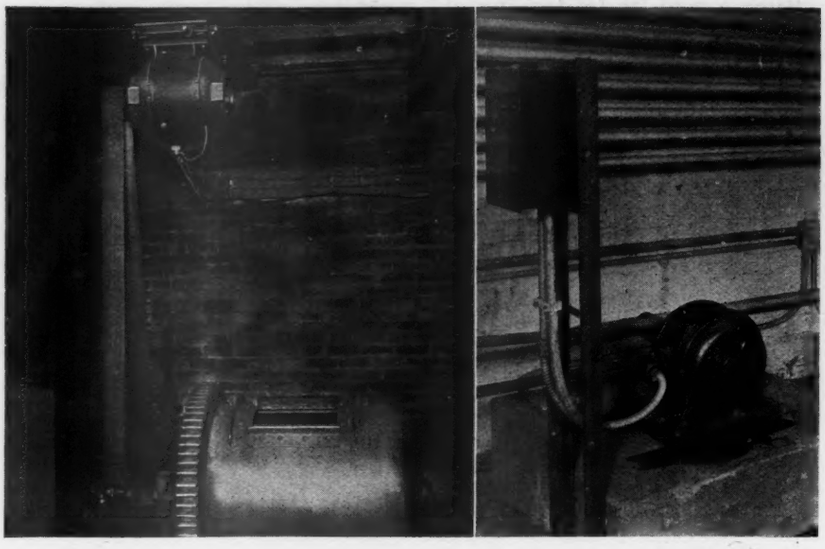
Start-stop buttons or push button stations are usually located as near to the operator as possible, depending of course upon the frequency of use. In the case of machine tools they are best located directly on the machine. Drum master switches are often used for starting, stopping and reversing machine tools. In illustration *G* on page 276 is shown a drum master switch that is operated directly from the apron of the lathe.

Auto-starters, unless remote controlled, cannot be mounted so conveniently for the operator, but when used the starting and stopping of the entire drive is not so frequent. Consequently, auto-starters or compensators are commonly mounted on a column near the drive. However, the auto-starter should not be placed on the opposite side of the machine so that in an emergency the operator has to duck around the machine or climb over a pile of machinery or material to get at the starter.

Speed regulators such as field rheostats should be located near enough to the operator so that he can stand at his work and adjust the speed to suit the job. However, safety must not be sacrificed to convenience in this matter. In any case field rheostats must not be located in exposed positions where there is a possibility of their being hit and damaged.

Inspection and maintenance should be considered when locating this auxiliary equipment. Drum controllers should not be located too close together or too close to surrounding structures, for when the maintenance man has to stand on his head





It is a shame to disgrace a motor with such poor wiring.

I know that you will agree with me when I say that I much prefer the installation at the right, for it looks like it was put in by a man who knew how. Notice the neat way the conduit is clamped to the framework, how flexible metallic conduit is run to the motor condulet, the strong mechanical connection between the flexible conduit and the rigid conduit, and the motor condulet. You can't help contrasting the wooden foundation of one installation with the concrete base of the other, the unsightly wiring with the neat appearance of the conduit and the open motor terminals with the motor condulet. The man who installed the job at the right omitted putting the padlocks on the control enclosures.

or squeeze himself into a very tight place, you can almost be sure that he will only make an inspection when he has to, and that usually occurs on a breakdown, when it is too late to take preventive measures.

Control panels should be accessible from both sides. If totally enclosed, the rear of the enclosure should have doors the same as the front.

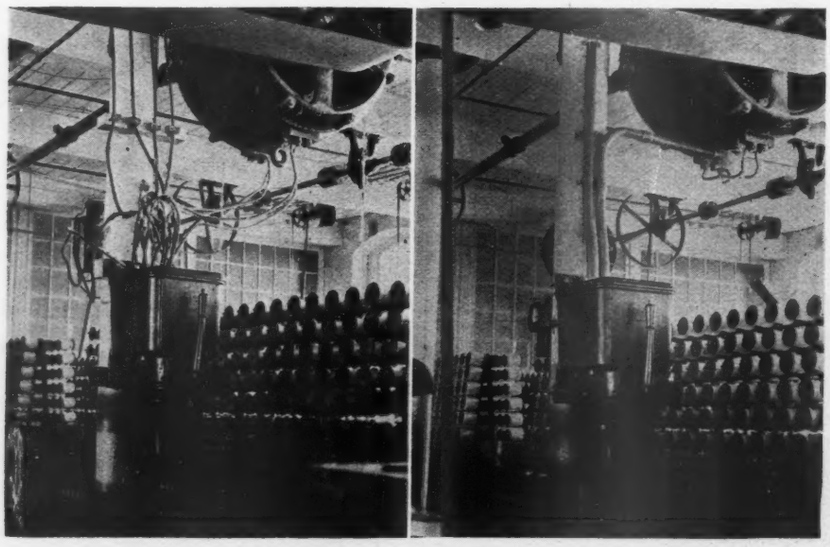
Resistors are usually located overhead and high up. In such cases provision should be made for a walkway or steps so that the resistors may be easily reached. Resistors should not be located too close together, not only from the standpoint of ventilation but also because room is needed around them to change frames or boxes, and to tighten connections. Resistor frames should not be stacked one on top of the other, for in case a quick change is required it is always inconvenient to change those on the bottom of the pile. I have always found it best to place resistor frames in a row on a rack and tier the racks. The rack should be of wood or some better insulating material. Although the end plates of the resistors are insulated from the grids, I have found that the insulated rack is well worth the trouble of installation. Due to the expansion and contraction of the frames from heating and because the grids cannot be enclosed from the dirt of the mill, the heat and dirt sooner or later break down the insulation to the end plates. When this happens with resistor frames mounted on steel racks an immediate shutdown is often required; with a similar occurrence on a wood rack no shutdown is required, in fact, the failure is usually unnoticed until the equipment is inspected.

Marking the ends of wires with metal tags will be found a great help in shooting trouble and in changing equipment. The marking should be such that the two ends of the same wire may be readily identified and show where they are to be connected.

In many plants the foreman in charge of construction puts in the job according to his own ideas and quite often he is influenced by the ease of installation rather than by the ease of operation and maintenance. To counteract this, some plants require the construction foreman to confer with the electrical maintenance foreman as to how the equipment should be put in so as to provide for ease of maintenance. In one large plant I recently visited, the electrical maintenance foreman in charge of a geographical division of the plant supervises the installation of all electrical equipment. There is a construction foreman who has charge of the construction gang and he directly supervises the work, but it must be installed to suit the electrical maintenance foreman. Since the maintenance foreman has to make the equipment operate, it is no more than fair that he should have considerable authority as to how the equipment is to be installed.

Ease of Construction Should Be Considered in the Layout

After an installation has been considered from the standpoints of safety, continuity of operation and convenience of operation, ease of construction should receive consideration. There are many ways to make a job easy to erect, but if they interfere in any way with the safety, reliability *(Continued on page 281)*



Here is what a little conduit, a few fittings and not a great deal of labor will do.

We all know that the installation on the left is sloppy, that it invites rapid depreciation of wiring and insulation and will soon lead to dangerous operating conditions. In fact, it was when the operator complained of shocks that the wiring was changed, as shown in the right-hand illustration. The cost of the change was about $18, and it would not have cost even this much if the work had been properly done in the first place.

An emergency method of rewinding a turbo-generator field.
The rotor was blocked up on the small turntable and revolved by the six men on the ends of the two sweep arms. The man sitting on the box is guiding in the copper-strap winding. Next to him is a man driving the strap straight in the slot and making it lie snugly. The man on his knees is guiding the insulating tape between the turns of copper strap of the coil. A man behind the girder on the right kept tension on the copper strap.

Here Are Details of the Job of

Rewinding the Field Of a Turbo-Generator

In Record Time Together with the Materials, the Emergency Methods and Ingenious Tools Used in Doing the Work

By A. C. ROE

Repair Superintendent, Detroit Service Dept., Westinghouse Electric & Manufacturing Company

AN IMPORTANT turbo-generator supplying power to an industrial works was partially under water during a flood. After the flood had subsided the armature or stator winding of the machine was dried out, tested and found to be in a satisfactory condition. The field winding, however, was damaged beyond hope of any temporary repair. This was due to the fact that the rotor slots were deep and that the asbestos insulation between turns soaks up water like a sponge. It would have been practically impossible to dry out such a rotor winding. It was decided, therefore, to rewind the rotor.

This turbo-generator was rated at 2,500 kw., three phase, 25 cycles, two poles, 1,500 r.p.m., 2,200 volts. The rotor weighed about 7½ tons and was 3 ft. in diameter. With the end discs removed, the length of the rotor was 55 in. The rotor was rather large to attempt rewinding at the power house; so it was shipped by auto truck to our service repair shop where there were better facilities for rewinding a machine of this sort.

WHAT would you do if the field winding on one of your turbo-generators should fail beyond hope of repair? Here is an account of a field failure, due to the rotor being water soaked from a flood, that meant a daily loss to the works while the turbo-generator was out of service. What was done, how it was done, the emergency methods and ingenious tools used in rewinding the rotor together with the procedure used to cut down the time required for the repair, are fully described in this article.

The job was undertaken with the understanding that the work of rewinding should continue day and night, as the inability to use the machine meant a daily loss to the concern.

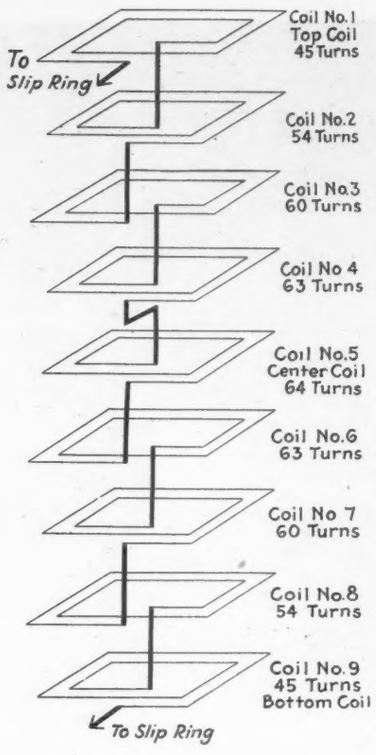
As soon as it was decided to rewind the field, an order was placed with the East Pittsburgh works of the Westinghouse Electric & Manufacturing Company, the generator manufacturer, for the required winding details, such as moulded mica cells, asbestos tape, corner blocks, and connectors. These were to be brought direct from the factory by special messenger.

As soon as the field was received, the end discs and the slot wedges were removed, thus exposing the winding. A walking beam was rigged up on the hook of one of the shop travelling cranes. From one

end of this beam was suspended an empty cable reel. The other end was arranged so that weights could be added to balance the reel as it was filled. The copper strap was unwound from one slot at a time and wound on to the reel by swinging the beam around the rotor. One man pulled the copper strap out of the slot, another wound it onto the reel, while two more men moved the beam so as to revolve the reel around the rotor.

There were nine coils in the field winding, one in each slot. Each coil was wound on a separate reel and the beginning and end of the copper strap from each coil was stamped with a die so as to identify it. This was necessary, inasmuch as the coils were of five different lengths due to the difference in the slot lengths at the ends of the rotor. Sixty-five hundred feet of copper strap 1 3/16 in. by 3/32 in. was removed from the rotor.

After all the coils had been removed, the old insulation was scraped out of the slots and the slots were thoroughly cleaned. Each coil was unwound from its reel and wound on to another while the kinks in the strap were straightened and the splices remade. The splices were originally made with rivets and half-and-half solder. These were cut off at each end of the splice and the ends heated to a cherry red and pounded to a tapered fit; then they were filed clean and silver-soldered. Silver solder is a combination of silver and copper and has the advantage over the half-and-half solder of having a much higher melting point and, along with it, considerably more strength.


To Slip Ring
Coil No.1 Top Coil 45 Turns
Coil No.2 54 Turns
Coil No.3 60 Turns
Coil No 4 63 Turns
Coil No.5 Center Coil 64 Turns
Coil No.6 63 Turns
Coil No 7 60 Turns
Coil No.8 54 Turns
Coil No.9 45 Turns Bottom Coil
To Slip Ring

The rotor winding has nine coils wound in nine slots.

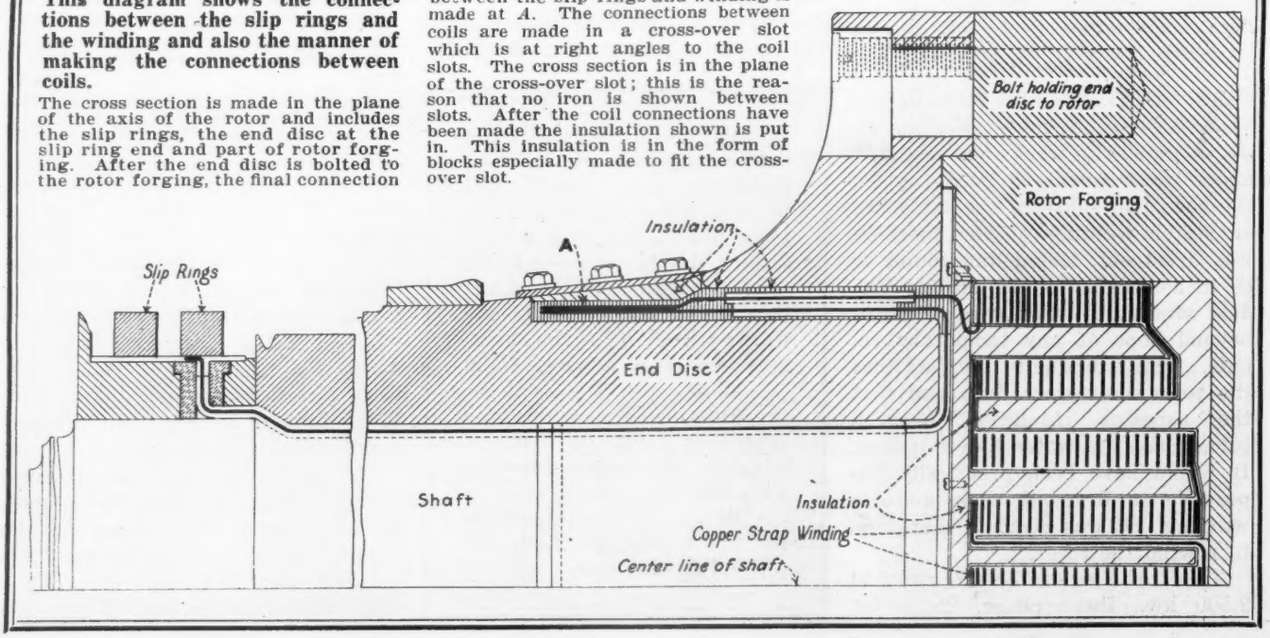
The number of turns is marked opposite each coil. The heavy lines are the connections between coils, which are made in the cross-over slot shown in the drawing at the bottom of the page.

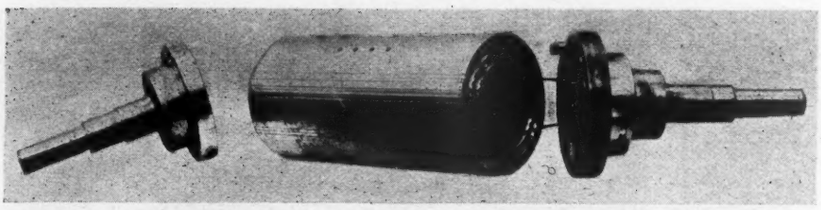
By the time the rotor had been stripped and cleaned, the cells and other winding details had arrived from the factory. The cells were made of moulded mica 0.040 in. thick. There were four cells and eight half cells or corner pieces per slot. The cells and corner pieces were so arranged that the top layer of the cells overlapped the bottom layer of the corner pieces. After the cells and corner pieces were in place in the slot, two thicknesses of 0.020-in. mica strip were put in the bottom of the cells to prevent the first turn from cutting through the cell.

The rotor was blocked up on the rotating platform of a turntable obtained from a local contractor. There was not time enough to rig up a power-driven turntable; hence the manually-driven one shown in the illustration on page 279 was used. Six men were required to turn the machine due to its weight and the tension required on the strap copper that was wound in the slots. This tension was applied by means of two fiber blocks bolted together with four bolts; the strap passed between the two blocks, and the tension was regulated by tightening or loosening the bolts. This device was fastened to the girder at the right in the illustration at the beginning of this article. One man was required to regulate this device, while another (the one sitting on the box in the center in the same picture) guided the copper into the slot. The copper had to be tilted as it entered the slot, so another man drove the strap straight in the slot and made it lie snugly. At the left of the picture is a man feeding the asbestos insulating tape (0.007 in. thick) which was the insulation between turns of the coil. Ten men were required per

This diagram shows the connections between the slip rings and the winding and also the manner of making the connections between coils.

The cross section is made in the plane of the axis of the rotor and includes the slip rings, the end disc at the slip ring end and part of rotor forging. After the end disc is bolted to the rotor forging, the final connection between the slip rings and winding is made at *A*. The connections between coils are made in a cross-over slot which is at right angles to the coil slots. The cross section is in the plane of the cross-over slot; this is the reason that no iron is shown between slots. After the coil connections have been made the insulation shown is put in. This insulation is in the form of blocks especially made to fit the cross-over slot.





The end discs are bolted to the rotor forging above and below the parallel slots in the forging.
The rotor shown here is similar to the one on which the repairs were made. The only difference is that it has ten slots instead of nine.

shift on this part of the operation.

The coils were wound in the slots and connected as shown in the diagram on page 280. The connections between coils were made through a cross-over slot. The cross-over slot is located on the slip-ring or lead end of the rotor and is at right angles to, and cuts through, the coil slots. It is slightly deeper than the coil slots so that connections can be made from the starting ends of the coils. The connectors are of strap copper bent to pass through the cross-over slot and connect to the coil ends. The connectors are silver soldered to the coil ends.

The last two turns wound on each coil were taped with ¾-in. mica tape 0.004 in. thick, the next to the last turn having one layer half-lapped and the last turn having two layers half-lapped. This was done to insulate the last turns from the wedges.

When all the coils had been wound in, the slots were filled at the corners with asbestos blocks, the cross-over slot was filled with asbestos blocks and the wedges were driven in.

As each coil was finished it was given a dielectric test between the copper and ground of 3,500 volts, from an alternating-current, 60-cycle supply. The complete winding after it was finished was given a similar test with 2,500 volts for one minute.

The rotor was now ready to have the end discs put on and the connections made to the slip rings. These connections were made as shown in the diagram on page 280. The connector from the top coil is pulled through the passage in the end disc as shown in the diagram. After the end disc has been bolted to the rotor forging, the connector from the slip ring was spliced to the winding connector as shown at *A*. The same thing was done with the connector for the other end of the winding and the connector to the other slip ring. This is done on the other side of the shaft. This diagram also shows the manner of making the connections between coils in the cross-over slot.

Rewinding this rotor required a period of ten days. It was then sent back to the power house from which it came, installed in the turbo-generator, and after being tested and balanced it was ready for service.

Ten men were required per shift on this rewinding job.
Six men, three on each sweep, turned the rotor; one man adjusted the tension on the copper strap (this man is behind the girder) two men are guiding the copper and insulating tape, while the tenth man is driving the strap so as to make it snug.

Improving Wiring Around Machinery

(*Continued from page 278*)

or convenience of operation of the drive they should be discarded. Conduit and wiring should be installed with the idea that the wires will become grounded within a few weeks and it will then be necessary to pull out all of the wires. If this thought is kept in mind, everything will be large enough to do a good repair job and consequently less trouble and scheming in finding out how to go about it will result.

Large junction boxes often make a job much easier to wire, especially if there are a considerable number of pipes that can be brought together at one point. I recently saw one job in which a very clever use of junction boxes had been made. It was on a hot metal crane of an open hearth. On this crane the cab is a long leg that reaches nearly half way to the ground. This leg is divided into four stories. The bottom story contains the master controllers, of which there were six (a two-trolley crane with three separate hoists) and the crane protective panel. The three upper floors contained the control panels. The supply came from the collectors at the top of the cab. Large junction boxes were located on the back of the cab, one to each floor. These junction boxes were about a foot high, and extended the full width of the back of the cab. The proper number of conduits were run vertically connecting the junction boxes; also, conduits were run horizontally from each junction box to the control panels on the corresponding floor and also from the bottom junction box to the master controllers. Conduits were run from the main collectors and from the trolley collector bars to the top junction box. Here was a simple way to wire six control panels, nine motors and six master controllers in a very accessible manner, using no excess conduit and taking up a minimum space for wiring.

Elbows should be used wherever possible instead of a condulet with outlets at right angles because they cost less and wire can be pulled through them more quickly and easily. However, with the larger sizes of wire it is not always easy to pull the wire around very many elbows. The 1923 (*Continued on page 305*)

A GREAT DEAL of uncertainty prevails as to the methods and the value of potential to be used when making dielectric tests on equipment that has been in service for some length of time. This article discusses these subjects from the operator's viewpoint and also outlines the steps to be taken and the things to look for before the insulation is tested for defects by the application of high voltage.

How to Check Up the

Insulating Condition of Windings

In an A. C. Machine Together With Inspection Procedure and Cleaning Methods Before Making Dielectric Tests

Dirt should be removed from all accessible parts of the winding. Loose dirt can be brushed off by wiping or by compressed air. Oil-soaked dirt may be removed with gasoline, benzine, or carbon tetrachloride. Important places to clean are the points where the coil is adjacent to the slot and around the clamping supports, as well as where the end turns cross each other.

ONE OF THE fundamentals of successful operation of electrical generating equipment is frequent, thorough, and systematic inspection. Such inspection will often give warning of approaching trouble and thus allow the operator to take precautions that will prevent a serious breakdown and consequent damage to the generating equipment.

It is the practice in some plants to inspect each generator every day. This is an excellent precaution and highly recommended. It is understood that operating conditions may not permit such frequent inspection but nothing should interfere with the thorough inspection of each machine as soon as it is shut down. No definite rule can be laid down, but the principle should be recognized that frequent inspections are vital to the proper maintenance of all generating equipment. All inspections should be thorough. While a casual inspection is perhaps better than none, the value of an inspection depends on the care used in making it.

The inspection should always include the armature windings and field coils of the main generator, insofar as they are visible and accessible, the armature, field coils, and commutator of the exciter (if there is one), the collector rings, all brushes and brush-holders, bolts, nuts, dowels and all other mechanical and electrical parts and fittings. Lubricating oils are injurious to insulation and also to concrete foundations, and all bearings and oiling systems should be examined for oil throwing and leaks. In the case of steam turbines, the turbine itself so far as possible, and the valves, valve gear, governor, throttle, governor-control motor, bearings and all other accessible parts should be included.

Haphazard inspection by anyone in the plant cannot be considered systematic. A definite routine of inspection should be standardized and every part should be taken up in order. Superintendents should compile a list of all parts subject to inspection and insist that inspectors use this list, checking off each item as it is examined. The inspector should be thoroughly familiar with what to look for and should be drilled in his work so as to guard as much as possible against the omission of any part.

Ways of Cleaning and Preserving Insulation of Windings

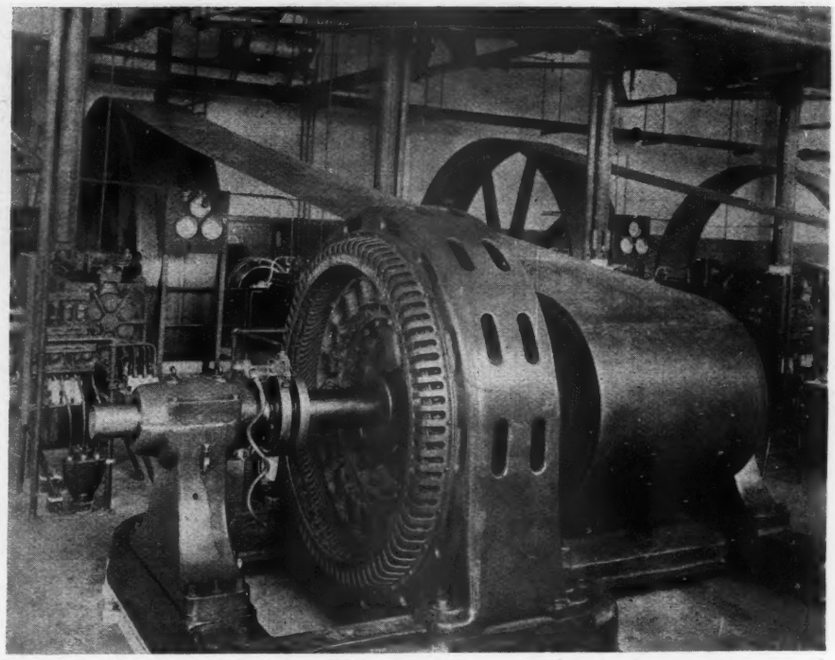
All generating equipment will accumulate dust and dirt in the course of time; even the use of air washers does not altogether eliminate this trouble. This dust and dirt lodges in the air ducts and on the ends of the windings, interfering with the free circulation of the cooling air and the radiation of heat from the windings, and at the same time increases the fire hazard.

The life of generating equipment may be prolonged by frequently blowing out the dirt with compressed air. In large turbo-generators this is a difficult matter, if indeed it is possible, owing to the design of the generator frame and end bells. On other types of machines, however,

such as engine-type generators, the air ducts and windings are more exposed and are accessible for this form of cleaning. If possible, the compressed air should be used every day but, before doing so, care should be taken to make sure that the air stream is free from water.

All generating equipment should be thoroughly cleaned once a year or more, if operating conditions are such as to require it. Special attention must be given to machines operating in localities where the air is contaminated with dust, lint, coal, dirt, cement dust, and the like. Under such conditions, arrangements should be made for a thorough cleaning at frequent intervals. To insure that this periodic cleaning be thorough, the end bell covers and similar parts should be taken off to expose fully the end turns of the windings and the air ducts. The revolving field should also be removed, so that it can be cleaned and examined, and at the same time permit the cleaning and inspection of the inside of the armature.

Loose dirt can be removed by wiping, brushing, the use of compressed air, bellows, or by some form of vacuum cleaner. Should dirt and dust be lodged with oil, it may be reremoved with gasoline. benzine or carbon tetrachloride. In using any of these, limit the quantity to that required for the purpose in hand. Too much liquid is liable to flush the dirt into inaccessible places. After using any of these solvents, all the surfaces to which they have been applied should be carefully and thoroughly dried. Care should be exercised when using gasoline or benzine because of their inflammable properties. Special attention should be given to ventilation, not only because of the danger of explosion but also because the fumes of all three are injurious to the workman, particularly if working in a pit where fumes are likely to collect. In using gasoline care should be taken to obtain a good quality, since a poor quality is liable to leave a coating of oil or other substance on the windings and in inaccessible places, which will cause the rapid accumulation of dirt and dust. Test all gasoline that is to be used for cleaning purposes, by allowing a small quantity to evaporate in a porcelain dish. If the quality is good, no residue or odor will remain. After cleaning and before re-assembling the parts, spray the exposed windings with a high grade of air-drying, insulating varnish. While the machine is disassembled, all electrical parts and connections and all mechanical parts should be carefully examined and such tests applied as may be considered advisable.



Engine-type machines such as this are easy to clean.
By sliding the stator to the left the stator winding is exposed for cleaning and all portions of the rotor are made accessible for maintenance work.

General Procedure for Making Dielectric Tests

No definite rules can be established for testing generating equipment that has been in operation for any length of time. The permissible test depends particularly on the age of the machine, on the character of the service to which it has been subjected, and on the type of insulation used on the windings. All insulation deteriorates with age and use, particularly where organic material forms a large part of the total insulating material. An old machine or one that has been subjected to severe operating conditions will not stand, nor should it be subjected to, the same test that might be applied with safety to a comparatively new machine.

There comes a time in the life of all equipment when the deterioration reaches the point of breakdown and, when this occurs, expensive repairs are usually the result. For the purpose of enabling operators to determine the approach of this condition, various tests have been devised and are now in use.

The "megger" and other similar devices are frequently used to measure the resistance of the insulation. There are many factors which call for experience and good judgment in interpreting the results obtained with these instruments; however, they are very widely used.

The combination of high voltage (at least as high as that of the machine under test) and direct current gives very satisfactory results. A new way of obtaining this combination is by the use of the kenotron measuring set. With this set the condition of the insulation is determined by measurement of the leakage current through the insulation to ground.

There frequently arises the question of applying a high-potential test, or what might be called a generated over-voltage test (running the generator at over-voltage by increasing the excitation or speed, or both) to determine the condition of the insulation. The answer must take into account the various insulating materials used, the age of the machine, and the operating conditions, particularly regarding overloading and periodic examination and cleaning. General approval in the abstract, at least, will be accorded the statement that "the insulation of all generating equipment should be maintained in such condition as to withstand safely the application of a 50 per cent over-voltage test." (*Continued on page 306*)

This photograph was taken in the repair shop of Huntington & Guerry, Greenville, S. C., and shows dipping and varnish tanks and drying ovens used in connection with motor and transformer repairs. After dipping and baking operations, a coat of air-drying varnish applied by brush or spray provides an insurance against breaks in the continuity of the baked film.

Here are Some Practical Suggestions on

Best Ways to Use Insulating Varnish

When Protecting Windings Against Moisture, Oil, Metallic Dust and Insulation Troubles Arising From Various Other Causes

By H. L. HAZELTINE
Engineer of Insulation, The Sterling Varnish Co., Pittsburgh, Pa.

BEFORE attempting to decide on the insulation for a given piece of apparatus, the nature of the service to which it is to be subjected must first be carefully studied and the proper kind of varnish chosen that will give the best results.

Next the structure of the apparatus should be examined closely, particularly as to the insulation other than varnish that has been used, so that the method of applying the varnish may be so varied as to provide the exact degree of protection desired. The general type of the liquid insulation will not be changed by the type of the coil, but it may be necessary to change the consistency at which the material is to be applied.

When insufficient attention has been paid to these details trouble is quite often experienced and it has been the custom in the past to lay these difficulties at the door of the particular varnish used. The rule then seems to be to change the varnish without further investigation. Occasionally the problem may appear to be solved—not because the new varnish is a cure-all but because the method of treatment happens to be right for the particular kind of work involved and the particular kind of varnish used. But when attention is directed to a new job, the trouble often returns and the same process of changing varnishes has to be gone over again. The source of the difficulty often actually lies in some minor change that has been made in the manufacture or design of the apparatus. The trouble can then be remedied by modification in the method of treatment. For example, a change from an untreated cotton tape to a varnished cambric tape demands a change, not in the varnish, but in the application.

Considerable throwing of varnish has been noticed in the case of high-speed armatures where a change has been made from a partially-closed slot to a straight slot. This was not due to a change having been made in the varnish formula, as was first supposed, but to the fact that the

throwing was never observed with the former design, although it did occur.

It is not always necessary to change the type of varnish when trouble develops unless, of course, the results previously obtained were not all that was to be desired and unless these results cannot be improved upon. Sometimes a modification of the treatment solves the problem.

It will be impossible in this article to discuss the proper way of handling all kinds of work. It will be necessary, therefore, to confine ourselves to a discussion of the general principles involved in securing specific results and leave the variations to be worked out by the individual.

In describing the different methods of varnish treatment to secure protection against the various external conditions such as water, acids, oil and metallic dust, it must be remembered that we are dealing with simple cases, such as where water resistance is the sole consideration. Hence in our selection of the proper material we are not allowing ourselves to be influenced by such considerations as the mechanical or binding strength demanded, or other complications, such as water resistance plus oil resistance. The methods of treatment will be the same. The only variation necessary will be in the nature of the varnish used. It is believed that the user, once he understands the simple principles involved, will be able to so combine the recommendations made with his previous knowledge of varnish as to enable him to adjust his methods to the most complicated cases.

TO SECURE the proper electrical insulation for a particular job is a problem in which guesswork cannot be successfully used, especially when it comes to the matter of varnish application. When the fundamental principles involved are once thoroughly understood, however, the details of the actual work are not at all difficult. Insulation against electrical stress calls for a procedure that will provide for external or atmospheric conditions and mechanical strains. In this article Mr. Hazeltine takes up the practical details of methods that can be used under different operating and service conditions.

Making Coils Waterproof

Case 1—Treatment of Coil without Impervious Insulation for Low-Voltage Service.—The simplest case is that of the coil wound with cotton-covered copper wire and then taped with cotton or linen one-half lapped, having no impervious insulation to retard the passage of the varnish into the coil.

To obtain perfect moisture resistance the varnish chosen should be one that has been carefully designed so that the dried film will not only shed water but will not absorb any through its surface.

The service which will test the protection obtained to the utmost is when the finished coil is to be operated on low voltage intermittently and subjected to atmospheric moisture. This is much more severe than high-voltage service, even when coils are actually submerged in water, because there is little heat generated in the coil itself and hence the moisture that may penetrate will not be driven off again in the form of vapor, as would be the case in the latter service.

General Requirements.—To insure perfect moisture resistance, it is absolutely essential that the coils be completely sealed. That is, the coating of varnish must be perfectly smooth and glossy and there must be no breaks in the continuity, such as cracks in the varnish film. Furthermore, all untreated tape is covered with many fine hairs which tend to pierce the varnish coat. When they do their action is like that of a wick and moisture is drawn from the air by capillary attraction into the interior of the windings. These fibrous hairs must be completely covered and many coats of varnish will be required. Time and production expense can be saved by singeing the coils before varnish treatment. This can be done by drawing them rapidly through an open gas flame, taking particular care that the movement is sufficiently rapid so that while the hairs are burned off the tape does not actually catch fire. This will remove most of the hairs but, of course, some may be left which must be covered.

Method of Application. — First heat the coils in an oven at 212 deg. F. for a sufficient length of time to drive out all moisture and occluded air from the windings. This preheating is important, since the varnish cannot completely fill the coil and so conduct the heat from the interior as long as stagnant air or moisture remains. Remove the coil from the oven and immerse it while still hot in a tank of varnish and allow it to remain until all bubbling has ceased, and longer if possible. The air in the coils being rarified draws the varnish into the interstices. When bubbling stops it is an indication that the varnish has replaced the air fairly well, but the action will continue for about 15 or 20 min. longer.

Withdraw slowly and drain for a sufficient period to allow the varnish to partially set. Too much emphasis cannot be laid upon proper draining as otherwise the varnish may collect in pockets and make the thorough drying very difficult. Next place the coil in a well-ventilated oven and bake at any temperature desired that will not injure the fibrous insulation. It is advisable during this bake to reverse the position of the coils so that the top during draining is at the bottom during baking. This insures a much more uniform coating, since the first effect of the heat upon the varnish is to soften it and cause it to flow. By this reversing the heavy accumulation on one side is largely avoided.

Upon removal from the oven, sandpaper lightly so as to smooth down any unevenness caused by the fibres that may have been left after singeing.

The first application is the filling coat. Since the varnish contains considerable solvent which on evaporating leaves some space unfilled, other applications must be made in exactly the same manner in order to secure the perfect seal already described. Even with the careful singeing and sandpapering, several applications will be necessary—three or four at least. This may be followed by a coat of air-drying varnish applied by brushing, dipping or spraying. The function of this latter material is simply an insurance against any breaks in the continuity of the baked film.

Unfortunately this elaborate process of treatment is costly. It is, therefore, recommended only where the moisture condition is severe and extreme measures must be taken for protection.

In order to cut down production costs many shops omit the singeing and sandpapering operations alto-

gether, although they serve to reduce the number of coats required. In such shops as many applications of baking varnish as are practicable are applied and are followed by one or more very heavy applications of an air-drying or finishing varnish. In this method, since much dependence is placed upon the air-drying product, care must be used in its selection. Results obtained by this practice are surprisingly good.

Remarks.—It matters little how the final protection is secured so long as it is borne in mind that perfect moisture resistance can only be obtained when a perfectly smooth, glossy coat of enduring varnish has been applied having no breaks in the continuity. Do not use an alcohol-solvent, finishing varnish to protect against extreme moisture conditions.

Case 2—Treatment of Coil without Impervious Insulation for High-Voltage Service.—As mentioned before, if this same simple coil is to be subjected to high-voltage service where considerable heat will be developed, such great care need not be taken to obtain the perfect seal, since the moisture which finds its way into the interior will be evaporated during the period of operation. Any type of baking varnish could be used with the expectation of obtaining good results, even though the coil were actually immersed in water during the operation. More care must be taken, however, to be sure that the coil is well filled. Dead air is a non-conductor of heat. If it is allowed to remain inside the windings it will, therefore, prevent the free passage of heat from the interior of the coil to the exterior.

If an insulation test is to be made upon the finished coil it will be best to use the same amount of care in securing a perfectly covered and sealed outer surface as in the first case. Otherwise the moisture in the windings will give a low value to the resistance when taken cold, although during the operating period this will rise rapidly due to the heat generated. The same general method of application should be followed as has already been outlined in Case 1, with those variations necessary to fit the shop requirements of the individual.

Case 3—Treatment of Coils Having Impervious Layer Insulation for Low-Voltage Service.—We will next take a layer-wound coil having treated or untreated paper between each layer. It is almost impossible to thoroughly dry a varnish on the inside of such a coil by the application of heat from the outside, since the only places for the solvent to escape and for air to enter for the oxidation of the drying oils are through the ends.

Method.—When such coils are to be operated on low voltage thorough impregnation with varnish is unnecessary, since little or no heat will be generated which must be transmitted from the interior of the windings to the exterior.

It is best, therefore, first to preheat as before and then quickly dip while still hot into a bath of a very heavy, viscous varnish. Remove at once allowing the coil to remain only a few seconds at most. Drain and bake as before. The varnish being very heavy and the coil being in the bath for a very short time, little more than an outside coat will be obtained. The varnish should not penetrate much more than one-quarter or one-half inch. As many additional applications must be made as will be required to obtain the perfect seal before described.

Case 4—Treatment of Coils Having Impervious Layer Insulation Designed for High-Voltage Service.—When, however, coils of this type are to be operated on high voltage where considerable heat will be developed, thorough impregnation must be obtained.

Compound Method.—A solid compound could be used, forced in by means of the vacuum-pressure impregnation system, providing its melting point is sufficiently high so that it will not be liquified and run out when the coil is in operation. Finishing coats of an air-drying varnish should be applied afterwards so as to insure perfect water resistance. A baking product would not be suitable in this case because of the danger of liquifying the compound during the baking and forcing it out through the partially dried varnish film.

Varnish Method.—If a varnish is preferred it may be applied by brushing a thin coat on each layer as it is wound. A fairly rapid drying product should be used and the paper layer insulation drawn tightly so as to squeeze out as much solvent and excess varnish as possible. After the coil is wound it should be thoroughly baked, then taped and given additional surface treatments in the same manner as above.

Case 5—Treatment of Coils Wrapped with an Impervious Tape.—Coils which are to be wrapped with varnished cambric or Empire cloth after winding, such as motor

Armatures should be dipped vertically with the commutator end up. The varnish should be thinned to such a consistency as to give maximum penetration and clean draining. The commutator end should be up, otherwise varnish may lodge under the commutator bars and be carbonized by the heat in service, causing short circuits.

field coils, should receive one or more applications of varnish as described under Case 2 before the outside taping is done. Stay tape or clips may be used to hold the conductors together during this operation. After the varnish has been properly baked the clips may be removed and the varnished cambric put on, and over it the cotton tape. Then apply as many coats of varnish as may be required to provide a seal that will be perfectly impervious to moisture. These later applications serve not only to cover the cotton tape but to seal the edges of the treated tape underneath.

Treatment of Field-Coil Assemblies.—It is always good practice in the case of d.c. field coils, especially where the motor is subjected to heavy duty, to immerse and bake the whole frame in varnish after the coils have been bolted in place. This serves to cover any abrasions that may appear in the treated surface due to handling during assembly. If connections are made after the coil has been bolted down the process serves to cover the joints with a smooth glossy surface which prevents water from getting in and creeping down into the coil underneath the insulation.

Case 6—Treatment of Armatures or Stators.—It is the practice in many shops to wind armatures or stators of small size with white or untreated coils and then dip the complete armature in a baking varnish. If this is done some slight degree of moisture resistance is usually sacrificed in order to provide mechanical or binding strength as the purpose of dipping complete armatures is to hold the coils in place and prevent their vibration, to fill all cracks between coils so as to prevent the deposition of dirt or moisture, to seal the laminations and prevent their vibration, to cover the iron and prevent rust and to protect against oil which may be splashed on the windings.

Method.—The armature should be preheated and dipped vertically, commutator end up, in a varnish thinned to such a consistency as to give maximum penetration and clean draining. The commutator end should be up because otherwise varnish may lodge underneath the commutator bars and later be carbonized by the heat in service, thus causing short circuiting. Great care should be taken to provide thorough draining so as to guard against pockets of partially-dried varnish

Special attention should be paid to the oven.

Baking varnishes dry by oxidation and therefore require a considerable quantity of fresh air during the drying period. See that this air supply is properly assured and then see that the proper temperature is being obtained.

which may be thrown out by centrifugal force when the machine is in operation. It may be necessary in some cases to tilt the armature during the draining period to prevent this.

If the varnish is allowed to set partially before baking, the shafts and other iron parts may be cleaned by washing with benzine. The armature should be baked in a vertical position so as not to throw it out of balance by too great an accumulation of varnish on one side. If it is absolutely necessary to bake horizontally the armature should be rotated a quarter turn every 15 minutes during the first hour or two of baking. Several treatments should be given so as to obtain a smooth, glossy surface which will easily shed water.

Protection for the Weak Points.—It must be remembered, however, that this treatment alone will not produce an absolutely water- and moisture-proof job. An insulation resistance test may show up badly after the armatures have been in storage for some time. This test is usually made from coil to ground and hence one must look between the conductors and the core for the source of difficulty. The weakest points are where the coil enters and leaves with the iron. Special attention must therefore be paid to the slot insulation.

If Empire cloth or varnished cambric is used it may be put in the slots or it may be simply added to the coil insulation. If the latter is done it will be better to treat the coil first before assembly and before the tape is put on. In any case the impervious insulation should extend at least ⅛ in. beyond the ends of the slots so that the coil insulation will not be cut by the sharp edges of the outer laminations. It is the custom in the larger motors to treat the coils first in the manner just suggested. After the treated tape and the white outer tape have been put on they may be singed or sandpapered and then additional varnish treatments given to provide a smooth, glossy finish. The varnish for such work should be a somewhat elastic product; that is, one that when dry will not crack or peel when the coil is pulled or bent when it is assembled. After the coils are in place the complete armature should be given one or more dipped coats for the reasons mentioned in the first paragraph of this case. The varnish, however, for this latter operation should be of the hard, baking type since one of its chief requirements is mechanical strength to hold the coils in the slots and protect them against injury due to vibration.

Remarks.—One of the disadvantages in this practice of dipping and baking the complete armature is that when repairs are needed it is practically impossible to lift a coil and a complete rewind is usually necessary. On the other hand the coils do not have to be replaced so often, since burnouts caused by the wearing away of the insulation by vibration are largely eliminated. Another advantage is that insulation which is bruised in assembling the coils is completely covered and sealed. The advantages gained by the practice are so great that they completely overbalance the disadvantages.

Armatures that come in for repairs, particularly those subjected to heavy duty, should be thoroughly cleaned, given a single dip in varnish and baked in order to renew the life of the insulation. This is, of course, in case a complete rewind is unnecessary. Not only is the insulation renewed in this manner but laminations (*Continued on page 306*)

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, June, 1924

How Much Do You Know About Your Work?

A SUBSCRIBER recently wrote: "I have just received my first copy of INDUSTRIAL ENGINEER and read it from cover to cover. I am very much interested in it, particularly the Question and Answer Department. In order to prove this I am taking the liberty of sending answers to two of the questions asked by readers."

INDUSTRIAL ENGINEER is written for the men who carry the practical responsibility of keeping the electrical and associated mechanical systems of industrial works in proper operating condition. It constitutes a permanent record of their work and the methods used in performing this work.

The Question and Answer Department is conducted as a means of rendering the fullest possible service to the readers of INDUSTRIAL ENGINEER. It is the medium through which any reader can obtain the information he desires on any problem that comes up in his daily work. His question will be answered by other readers who have solved the same problem in a practical and satisfactory manner. Conversely, this department affords every reader an opportunity of helping his fellow workers in the solution of problems that are of mutual interest.

If one desires neither to ask nor answer questions he can still spend a very profitable hour or so in reading the new questions and determining for himself how many of them his experience or education would enable him to answer. These questions cover a wide range of practical problems in the installation and operation of electrical and mechanical equipment. They are a bird's-eye view of the maintenance problems encountered daily in the industrial works of this country. To answer a question may require the knowledge gained by years of practical experience; or it may depend on the proper application of some half-forgotten fact or principle.

In any event the list of questions published each month in INDUSTRIAL ENGINEER affords an excellent means of testing the quality and extent of your information and ability to handle the maintenance problems of an industrial works.

Read carefully the questions in this issue. For your own sake outline in your mind the answers to as many questions as possible. If you think your answers will be helpful to the readers who asked the questions—send the answers to us.

Possible Savings By Motor Rearrangements

IN ALMOST any plant where load tests on motors are not regularly made some surprising leaks can be discovered with a set of indicating and recording meters. In one particular plant where such a test was made on ten induction motors totaling 355 hp., it was found that six of them were underloaded to such an extent as to operate at an objectionably low power factor and that the friction load was 142 hp. By simply rearranging the motors so that the ratings were more suited to the maximum loads, one 25-hp. motor and one 50-hp. motor were discarded and the loads distributed among the remaining eight. By adjusting the belting and shafting the friction load was reduced from 142 hp. to 108 hp., the efficiency of the motors increased an average of about 2 per cent and the power factor of the motors increased from 3 to 12 per cent.

The cost of this rearrangement was $282, but the actual saving in energy required the first year after the change was $1,441, through a reduction of 30 kw. in the load which amounted to a saving in the power bill of 69,920 kilowatt hours.

This installation furnishes a practical example of the cost of negligence or indifference to simple maintenance problems such as adjusting belt tension, avoiding complication in shafting and drives through rearrangements of machinery, attention to lubrication, knowing the actual loads carried by motors and checking same with nameplate ratings, checking the actual time certain motors are standing idle, and other operating conditions that change with changes in arrangements of machines or the work done on them. An investment in a set of portable indicating and recording testing instruments and load checks on all motors at least four times a year will usually pay a nice profit. Besides, the data thus made available will eliminate a lot of guesswork when new power drives are to be installed.

What Makes A Good Wiring Job?

ONLY too often is wiring about machinery considered a matter of bending pipe and pulling wire. In the article on page 275 of this issue and the one that appeared in the May issue some other side lights, such as safety, continuity and convenience of operation, and ease of construction, have been thrown on this subject. Before the wiring job is considered complete and the machine ready for operation, a careful inspection should be made of all parts of the installation, followed by tests made on the apparatus controlling the machine.

This calls to mind the case of a 1,000-kw. rotary converter operating in a large industrial works. This machine was given a superficial examination and then started up and thrown on the line. For several months the machine operated satisfactorily; then during a

period of heavy production it failed due to a grounded field. Changing the field on this particular machine was a half-day's work for a gang of six men. Production in the plant was interrupted and an unnecessary loss entailed.

A very careful examination and test disclosed the fact that the field discharge resistance was incorrectly connected to the field switch. The field switch is opened and reversed on this machine only when it is necessary to "slip a pole" to make the direct-current polarity come right. It so happened that the polarity on this machine usually came right of its own accord without the necessity of slipping a pole. Consequently the field switch was rarely used. However, it was used often enough to cause the field insulation to break down.

Wiring about machinery is only half done when all the equipment is installed. Before the job is considered as complete, a careful inspection should be made of all parts, followed by tests of all connections and apparatus. Only after this inspection and tests should the machine be put in operation.

By-products of Paint-up—Clean-up Campaigns

INDUSTRIAL plant men after an application of good paint, brush and broom have noticed some interesting results which had not been entirely anticipated, unless these men had had similar experiences before and knew what would happen. Many of these campaigns are no doubt the application in industry of the good housewife's spring housecleaning. One of the best excuses for getting the average industrial man to apply white paint to the interior of factory buildings is, that he can get a greater application of light usually with a decrease in the lighting bill. A decreased accident hazard is another result which goes hand-in-hand with better lighting and brighter surroundings.

There is another point, however, which is not so generally considered—the effect upon the morale of the workers. For example, in one gas generating plant the operators were required to make written reports of conditions every five minutes. The reports had become so undecipherable that they could not be read and, in addition, the men made numerous mistakes through inability to decipher their own writing correctly and make proper subtractions and additions. The superintendent finally gave each man a broom and required him to keep the space at his own machine brushed up. An almost simultaneous improvement in the appearance and legibility of the reports was noticed with the cleaner floor.

In a large printing shop and bindery the superintendent insists on a clean shop. The men whose duty it is to prepare the glue at one time insisted that their room could not be kept clean because glue stuck so to the walls and floor. The superintendent ordered the whole room painted white so that they could clean any spattering of glue before it had time to dry. This removed the only excuse for a dirty shop. This plant specializes in high-grade printing and, according to the superintendent, could not maintain this quality if it were not due to the high standard of cleanliness and neatness required in the shop. After all, human nature is about the same everywhere and if you can't get around peculiar notions one way, try another. It will be more effective and less disagreeable than the "bawling-out" treatment.

Maintenance Is Not a Second Fiddle

PROPERLY maintained equipment never wears out and replacement of it is only occasioned by obsolescence, inadequacy, change in art, or economies and improvements. Facts to support this statement were given aplenty in the hearing on depreciation before the Interstate Commerce Commission last Winter.

Mr. L. F. Love, President of the Delaware and Hudson Company states in his testimony: "Depreciation postulates that anything to which it is applicable has a limited and calculable useful life, at the end of which it must be scrapped. There is no limit to the useful life of a composite railroad property. If the theory of depreciation is carried to its logical extreme, there is nothing left for repairs; if repairs are adequately made, there is no depreciation."

Mr. Sidney Z. Mitchell, President of the Electric Bond and Share Company, made a similar statement in his testimony. Mr. Alex Dow, President of the Detroit Edison Company, also testified that: "Generators have an indefinite life, with ordinary maintenance."

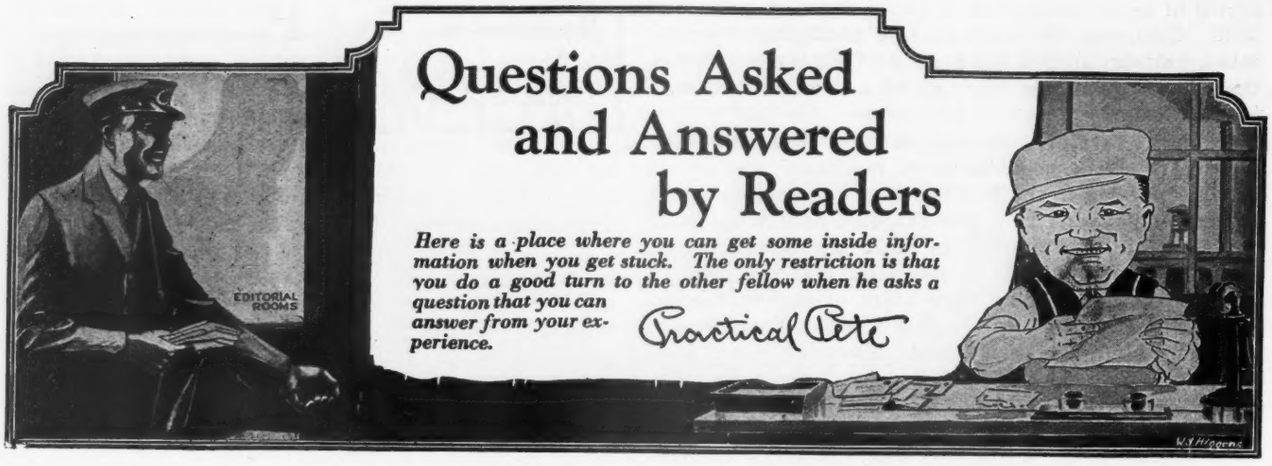
The late Robert A. Carter, Vice-President of the Consolidated Gas Company, in an address before the National Electric Light Association on Dec. 14, 1923, expressed his ideas regarding maintenance as follows:

"Unlike human life, which is limited, the product of human energy may have perpetual life. The sphinx, the pyramids, celebrated obelisks, aqueducts, bridges and other structures, as well as statuary, jewelry and articles of personal and domestic use and adornment have survived and will continue to survive for centuries. They represent nothing more than a rearrangement of indestructible matter. If Quintus Marcius had constructed a gas plant or an electric plant instead of an aqueduct in 144 B. C. nothing but neglect would interfere with its operation today. And, even though neglected, so much of the plant as consisted of steel, iron, concrete, stone, brick and mortar, which would represent nearly 100 per cent of the cost, would remain in substantially its original form. Stephenson's second locomotive was still in use in 1922. The cast-iron water pipes leading from the river Seine to the fountains at Versailles were installed in 1658, and the only repairs that have been necessary after two and a half centuries of service are the occasional replacing of bolts. Rome is still supplied with water by an aqueduct the construction of which was begun by Quintus Marcius in 144 B. C. Tunis is now supplied by an aqueduct built by Hadrian in A. D. 120. The aqueduct at Nimes has been in use for nearly twenty centuries. There are many other instances of masonry and concrete structures which have survived many hundreds of years of useful service.

"It is idle, therefore, to talk about the life of a utility's plant and equipment. The only matter of interest is its *maintenance in efficient service* by repairs, and its improvement by renewals and replacements to keep abreast of the development in the science of rendering utility service and to meet the growing demands of an increasing patronage."

Expressions like these put a different value on maintenance work than is commonly given to it. The usual plant manager expects his maintenance department to keep his machines running for ten or twelve years, when they will be replaced with new ones. Proper and adequate maintenance, according to the authorities quoted, would make these machines run forever. However, to attain this result in the industrial works high standards of maintenance will have to be attained—maintenance must not always play second fiddle to production and the maintenance men should receive the recognition they deserve.

To those interested in depreciation a booklet published by the Consolidated Gas Company of New York City, containing abstracts of testimony before the Interstate Commerce Commission, will be of interest.


EDITORIAL ROOMS
Questions Asked and Answered by Readers
Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.
Practical Pete

Who Can Answer These?

Alarm System to Indicate Hot Bearing—We have had considerable difficulty on some heavy pressure rolls due to bearings getting too hot before they were discovered. I have heard that it is possible to use an alarm system of some sort for indicating when bearings get beyond a certain temperature. Can any readers tell me how a device of this sort may be made and installed?
Gary, Ind. L. M. C.

* * * *

Card System for Miscellaneous Power Drive Equipment—The only storage space we have for miscellaneous pulleys, shafting hangers and similar parts is some distance from the room which serves as the repair shop and headquarters of the maintenance department. As we now have no system of keeping track of this material one of the men must go and search through it whenever anything is needed. I should like to know if any reader has worked out a card system that we could use to tell what we have on hand.
Kansas City, Kan. H. L. G.

* * * *

Selection and Application of Carbon Brushes—Can any of the readers of INDUSTRIAL ENGINEER give me any information on how to choose and properly apply the various grades of carbon brushes? I should like to know how a practical man can by inspection and simple tests choose a suitable brush for a job or determine what application a certain brush is most suitable for. I have seen references to the electrolytic action between brass collector rings and carbon brushes and should like to know the cause of this action and if there are any means of overcoming it.
W. A. P.
Smooth Rock Falls, Ont., Can.

* * * *

Testing Large D.C. Generators for Short Circuits—Will some one give me a good, practical method of testing for short circuits, large d.c. generators and motors, especially those having equalizers or cross connections? I have in mind machines of 1,000-hp. rating and over. In the various articles on testing which I have read, I have failed to find any mention of these connections and should like to know the procedure when testing out a machine which has them.
Ottawa, Canada. S. J.

* * * *

Grounding Secondary of 3-Phase, 220-440-Volt Distribution System—I wish some reader would tell me whether the secondary of a three-phase distribution system for 220-volt and 440-volt motors should or should not be grounded? Why? The Standard Handbook says: "The grounding of secondaries up to 150 volts has been required by the National Electrical Code since 1913. There is some doubt as to the advisability of grounding secondaries when the difference of potential between any wire and ground is higher than 250 volts, owing to the possibility that shocks from such a system may prove fatal." How could a person receive a shock from a grounded secondary system when the conduit inside of the building is also grounded? Would not trouble at once reveal itself? I shall appreciate it if you can enlighten me on the why's and where's of this subject.
Orlando, Fla. H. C. M.

* * * *

Will This New Winding Be Satisfactory?—I have a 2,200-volt, three-phase, 60-cycle, 20-hp. motor that I want to rewind for 220 volts, three-phase, 60 cycles. This is a squirrel-cage motor, having seventy-two slots. The original winding was seventy-two coils wound with twenty-six turns of No. 19 wire, two-parallel, connected series star, the coils laid in slots 1 and 10. Would a winding consisting of thirty-six coils of sixteen turns of No. 14 wire, three-parallel, coil span 1-and-16, be satisfactory? How should this winding be connected? I shall appreciate it very much if someone will help me out on this.
Albany, Ga. B. B.

Answers Received To Questions Asked

Does Voltage Above Normal Affect Power Bill?—We buy power from a local power company at a line voltage of 13,000 volts. The voltage in the plant is supposed to be 550, but we have an average voltage of 640 to 700. Our motors are of the induction type, ranging from 1/10 to 50 hp. Will there be any loss of power with the voltage higher than normal? If so, what will it amount to? When the voltage jumps from 620 to 700 our indicating wattmeter will rise around 200 watts. Will this increase the reading of our kw.-hr. meter in proportion, or what per cent will it be? I have been checking very closely the power consumed and find that when we have high voltage the power runs higher also. I shall be very grateful for any information you can give me.
Rock Hill, S. C. L. W. M.

Replying to L. W. M., in the April issue, it is practically impossible to give anything more than a general answer to his question, as the effect produced by voltage higher than normal depends a great deal on the electrical design characteristics, of a motor.

As a general statement, it can be assumed that an increase in the impressed voltage will cause an increase in the input wattage of the motor, in proportion to the square of the impressed voltage. Just how close this approximation will be, will depend upon the design of the motor. L. W. M. says that an increase of 200 watts resulted from a change of voltage from 620 to 700, but no comparison can be made in the absence of the initial reading of the meter before the change in voltage.

If the motors are rated at 550 volts and the actual voltages vary from 620 to 700, or 12.07 per cent to 27.3 per cent it may even be possible with closely designed motors to have increased losses, or in other words, increased power consumption for the same load, which may vary in greater proportion than the ratios of the squares of the impressed voltages. The design of the modern motor is based on its performance at a certain rated voltage.

Assuming the motor load to be constant, an increase in impressed voltage will increase the exciting current and the iron loss, and decrease the load current. The decrease in the load current may offset the increase in the exciting current for a very small increase in the impressed voltage, but for increases of more than 10 per cent, the exciting current in modern motors increases very rapidly. The iron loss increases very rapidly for all voltages above normal and is much greater than the increased copper loss, due to a higher current.

C. OTTO VON DANNENBERG.
The J. J. White Engineering Corp.,
New York, N. Y.

* * * *

In answer to L. W. M.'s question in the April issue of INDUSTRIAL ENGINEER, I would say that increased voltage increases the current in the stator, in addition to lowering the power factor and decreasing the slip. It will, in all probability, cause a temperature rise due to increased current in the stator. Now to get to the question, Will there be a greater power loss with a higher voltage?, the answer probably is yes, although this would depend, to a large extent, upon the proportion of primary copper loss and iron loss in a normal machine, and also the degree of saturation in the iron.

I notice that you are using an indicating wattmeter, as well as a recording wattmeter. I assume that you have no power factor meter and use the indicating wattmeter to determine the power factor. Nevertheless, the recording wattmeter reading increases in proportion, since they both get the

same voltage and current. I do not know whether you can do anything to reduce the voltage to its proper value, but if you can, I would do so, for, as a general proposition, induction motors operate at their highest efficiency at the current and voltage given by the manufacturer on the nameplate.

SGT. JAMES A. COOKE.
Observation Battery,
Fort Bragg, N. C.

* * * *

Trouble With Single-Phase Induction Motor—Can some of the readers of INDUSTRIAL ENGINEER tell me what is the matter with a small, single-phase induction motor which fails to start when the switch is closed? Both the main and starting windings and the centrifugal switch have been tested and seem to be all right. After closing the line switch and giving the rotor a quick start by means of a string, the rotor will sometimes quickly come to a stop, or apparently lock. Then, possibly the next time the switch is closed the motor will start from rest and run normally. This is a standard make of four-pole, 60-cycle, 110-volt motor. I shall certainly appreciate any suggestions you can give me as to what is the trouble and how it can be remedied.

Urichsville, Ohio. R. F. P.

Replying to the question asked by R. F. P. in the April issue, these motors are manufactured in large quantities and the air gap is not given the attention that the larger motors receive. If he puts the rotor in a lathe and takes off 0.001 in. he will not have any more trouble from the rotor locking and failing to start. The air gap clearance in these motors is small and the rotors are not perfectly true, so that at certain positions the rotor may lock magnetically. Then the motor will burn out if the current is not switched off, or the fuse does not blow.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Lumber Co.,
Springfield, Ore.

* * * *

In answer to R. F. P. in the April issuer, I would suggest that he test his starting winding leads by cutting out the switch and holding one side of the starting winding in his hand, with the other side connected to the running winding. Then close the line switch at the same time, having both windings connected across the line. After the motor stars, break the starting winding with the lead he holds in his hand. If the motor works satisfactorily he will find that the trouble is in his centrifugal switch. I believe this test will clear up the trouble that he is experiencing.

Albany, Ga. B. BELCHER.

* * * *

In reply to R. F. P.'s question in the April issue, I believe the motor he refers to has badly worn bearings, as this condition would cause the action that he describes. He might make a thorough examination to ascertain if the motor has any of the following defects, which may be easily determined by careful testing:

The starting coil may be short-circuited or burned out, likewise the running winding; these windings may be short-circuited together at some intermediate point as well as at one end. There may be two grounds in either winding, or one on both, which would constitute a short circuit. There might be an opening in the starting winding which makes enough contact occasionally to start the motor; this would cause the intermittent starting described. This opening could be in the centrifugal switch; that is, the springs that hold it closed may have lost their tension.

I do not think that the rotor is open, although it might be examined for loose bars. These small rotors give very little trouble.

Electrician, G. H. EMERSON.
Electric Repair & Service Co.,
Birmingham, Ala.

* * * *

Answering R. F. P.'s question in the April issue of INDUSTRIAL ENGINEER, if he is sure that the starting and running windings of his motor are O. K., and that the centrifugal starting switch is operating properly, he will probably find that the trouble he describes is due to worn bearings. Small induction motors have only a small clearance between the rotor and stator, and even slightly worn bearings will sometimes let the rotor drag, thus "locking" the armature when starting the motor.

We service a number of these motors driving electric pianos and in most cases find that when they begin to fail to start at times, the bearings need renewing. R. F. P.'s motor starts part of the time, due to the fact that the lubricant in the bearings sometimes forms a film sufficiently thick to raise the rotor clear of the stator. I hope that this suggestion will help him to remedy his trouble.

San Angelo, Tex. S. CURTIS EBNER.

* * * *

Effect of Armature Coil with Reversed Polarity—Sometime ago this question was raised in our shop: Will a reversed polarity coil in an armature burn out while running or what effect will it have on the armature?

I contend that in order to burn out a coil a heavy current must flow in that coil, which could only be caused by a short circuit. As all coils are connected in series, current of the same amount would flow in each; if one were reversed it would oppose the action of the others and having only the same amperage through it as the others it could only oppose with the strength of one coil, and would neutralize one armature coil.

I should like to hear from some of the readers of INDUSTRIAL ENGINEER on this question.

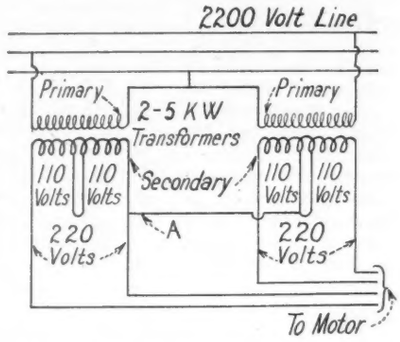
McKeesport, Pa. E. K.

In reply to E. K.'s question in the February issue, the coil will not burn out while running but it may cause unsatisfactory operation by bringing about an unstable magnetic condition of the armature. The latter will have two or more paths in parallel, depending on the number of poles and the type of winding, and inasmuch as the reversed coil opposes the remaining coils of the group of which it is a part, there will evidently be two less effective coils in the one group, as the reversed coil neutralizes one other coil, than there are in the remaining group or groups.

The amount of magnetic unbalance will be in proportion to the number of coils in the group. The effect on the operation of the motor will be an unbalanced torque, sparking at the brushes and a rise in the temperature of the armature.

Muncie, Ind. GEORGE CROPPER.

Trouble in Operating Two-phase Arc Welder Set on Three-phase Circuit—I had occasion recently to operate a two-phase, four-wire, 220-volt, 60-cycle, 1,800 r.p.m. 5-hp. Lincoln motor, which is direct connected to a Lincoln welding generator on a three-phase, 2,200-volt, 60-cycle circuit. The transformer connection shown was tried. I found that the motor would start but in a short time would get very hot. The wire at *A* was cut and then the motor did not heat so much, so that by stopping the machine about every hour and letting it cool off I was



able to do the welding, but too much time was lost. I wish some of the readers of INDUSTRIAL ENGINEER would tell me if this connection is correct, and if so, what causes the motor to heat.

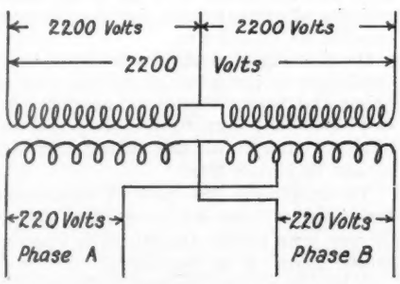
Tyrone, Pa. H. L. F.

In answer to the question by H. L. F. in a recent number, the connection which he is using is wrong, as he is in reality obtaining two single-phase currents which are not at right angles to each other. I would suggest that if one of his transformers does not have a tap on the secondary side which will deliver a voltage equal to 90 per cent of the voltage of the other transformer, he trade it for one which is provided with such a tap.

Assuming it is possible for him to get at the center of the secondary of the remaining transformer, the use of what is known as the Scott connection, which can be found in any handbook, should solve his problem very satisfactorily.

It may be difficult, or impossible, for him to make this exchange of transformers, or too much trouble, if the welding outfit is for temporary use only. In this event I would suggest that he use, as an emergency method, the connection shown in the accompanying diagram. This will not give a balanced condition but the results will be much better than with the present connection and there is the further advantage that the transformers now on hand may be used.

Clarkdale, Ariz. T. E. PEACOCK.



Emergency connection of transformers for obtaining 220 volts, two-phase, from 2,200-volt, three-phase circuit.

Correcting Power Factor by Synchronous Condenser—I wish to submit the following problem to our readers: *A* is a distributing station supplying power to four feeders, *B*, *C*, *D* and *E*; *B* takes 4,000 kw., *C*, 3,500 kw., *D*, 3,000 kw., and *E*, 2,000 kw. The power factor of these loads is: *B*, 80 per cent, *C*, 78 per cent, *D* 75 per cent and *E*, 72 per cent, all lagging. It is desired to install a synchronous condenser at station *C*, to give 95 per cent power factor. Would it make any difference in the size of condenser required at *C* if stations *B*, *D*, and *E* were to correct their power factor to unity instead of running at 80, 75 and 72 per cent respectively, as at present, (1) in case station *A* has ample generator and exciter capacity and (2) in case this capacity is just enough to carry the load?

Belleville, Ont., Can. J. H. G.

The question asked by J. H. G. in a recent issue of INDUSTRIAL ENGINEER presents an interesting problem. Neglecting the reactance of the distribution lines, which would probably be small in any case, we have a resultant lagging power factor of 77 per cent at station (A), determined as follows:

Feeder	Load in kw.	Power Factor	Load in kva.
B	4,000	80 per cent	5,000
C	3,500	78 per cent	4,487
D	3,000	75 per cent	4,000
E	2,000	72 per cent	2,778
	12,500		16,265

Kilovolt-amperes are determined from the formula, $\text{Kva.} = \frac{\text{Kw.}}{\text{P. F.}}$ Then for total load $\text{P. F.} = \frac{\text{Kw.}}{\text{Kva.}}$ or $\frac{12{,}500}{16{,}265} = 77$ per cent.

From this it will be seen that the total electrical capacity necessary at station (A) to supply these four feeders is 16,265 kva.

In installing a synchronous condenser at station (C) for correcting power factor, two courses are open. The first is to install a condenser of the proper size to raise the power factor of station (C) only, from 78 per cent to 95 per cent lagging. The second is to install at station (C) a condenser of such a size that it will have a leading power factor of a value to counteract the lagging power factor of the other three feeders and give a resultant power factor at station (A) of 95 per cent lagging. The first course will benefit station (C) but the benefit to station (A) will be small, as it can be shown, by calculations similar to those given above, that if the power factor at station (C) is raised to 95 per cent the resultant power factor at station (A) will be raised only to 81 per cent and the electrical capacity required decreased to 15,462 kva.

On the other hand, if a large enough condenser is installed at station (C) to bring the power factor at station (A) to 95 per cent lagging the electrical capacity required at the latter will decrease to 13,158 kva.

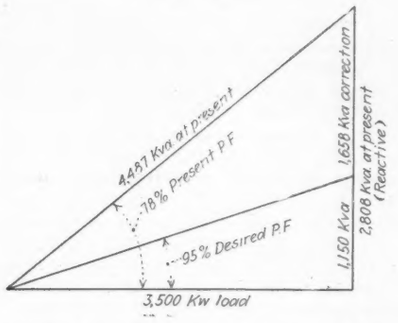
To determine the size of condenser for the first case, we have 3,500 kw. at 78 per cent power factor. The desired power factor is 95 per cent.

$$\text{Present kva.} = \frac{3{,}500}{.78} = 4{,}487 \text{ kva.}$$

$$\text{Present reactive kva.} = \sqrt{4{,}487^2 - 3{,}500^2} = 2{,}808 \text{ kva.}$$

Kva. at the desired power factor $= \frac{3{,}500}{.95} = 3{,}684$ kva. Reactive kva. at the desired power factor $= \sqrt{3{,}684^2 - 3{,}500^2} = 1{,}150$ kva. Then the corrective effect needed $= 2{,}808 - 1{,}150 = 1{,}658$ kva. The illustration will help to make this clear.

In a similar manner the corrective effect needed at station (C) to bring the power factor at main station (A) to 95 per cent will be found to be approximately 6,200 kva.



Graphic method of determining size of condenser needed for power-factor correction.

The size of condenser required at station (C) will be independent of the power factor at stations (B), (D) and (E), insofar as station (C) itself is concerned, but the effect of partial or total system correction will affect station (A), as has been shown. In case station (A) has ample generator and exciter capacity to carry the kva. load, the effect of power factor correction at one of the other stations is to reduce the line losses and heating and to improve the voltage regulation. If station (A) has only enough capacity for the kw. load, then either correction of the power factor of the whole system or the installation of additional capacity at station (A) must be resorted to.

It will be noted that the total load in kva. has been calculated from the arithmetical sum of the individual kva's. This is not strictly correct as the total kva. is actually the vectorial or geometric sum of the individual kva's. However, since the power factor of the individual loads does not vary by more than a maximum of 8 per cent, the error introduced by taking their sum is negligible.

The attention of J. H. G. is directed to the very excellent article on Power Factor by Mr. E. H. Hubert, that appeared in the December, 1922, issue of INDUSTRIAL ENGINEER.

Comerio Falls, Bayamon, Porto Rico. FREDERICK KRUG.

* * * *

Ammeters Connected for Three-Phase, Three-wire Circuits—I wish some reader of INDUSTRIAL ENGINEER would give me a wiring diagram of three ammeters used on a three-phase, three-wire circuit, using only two current transformers, and explain how the current passes through each meter.

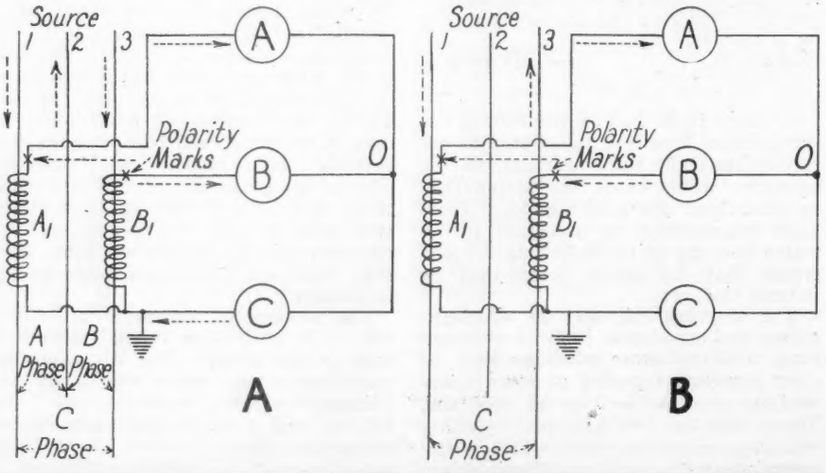
Haledon, N. J. G. Z.

In answer to G. Z. who asks in the August issue for a diagram and explanation of the method of connecting three ammeters to two current transformers on a three-phase, three-wire circuit, I wish to submit the following information:

This connection is known as the reversed "V" connection and is the one which is most frequently used for instruments of the indicating type.

First of all it is necessary that your transformers be connected up in accordance with their polarity marks. These polarity marks on instrument transformers indicate that with current flowing into the marked primary terminal at any instant the current in the secondary will flow out of the marked secondary terminal at the same instant. If we have a balanced three-phase load the three ammeters should, of course, all indicate alike, and there will be three equal currents, circulating in the three main wires, but their maximum and zero values will differ by 120 electrical degrees. However, to make the explanation clearer, we will assume an instant when the conditions are as shown in (A) of the drawing, where the current in No. 2 wire is maximum in a certain direction and the current in both outside wires, Nos. 1 and 3, is equal and one-half the value of the current in No. 2 wire, but in the opposite direction. Ammeter (A) indi-

Instantaneous direction of current flow in a system of three ammeters and two current transformers on a three-phase, three-wire circuit.



cates the current in line No. 1; ammeter (B) the current in line No. 3; and ammeter (C) the current in line No. 2.

The direction of the currents in the transformers will be as shown in (A), the current from transformer (A_1) flowing through ammeter (A), and current from transformer (B_1) flowing through ammeter (B). Now since the currents in the primary of both transformers are equal and in the same direction, the current in the secondaries of both transformers will be equal and in the same direction and meters (A) and (B) will give the same reading. These two currents unite at (O) and together flow through ammeter (C), which will show a reading twice that of (A) or (B), thus showing that No. 2 wire carries twice as much current as wires No. 1 and 3. However, at another instant we may have No. 1 and No. 2 wires carrying equal currents and the current in wire No. 3 would be double and opposite in direction, so that the current from the secondary of transformer (B_1) will be double and in the opposite direction to the current from the secondary of transformer (A_1). Therefore the reading of ammeter (B) will be twice that of ammeter (A). Then these two currents will join at (O), but since the current in (B) is double and opposite to the current in (A), we will have the difference, or a current equal to that flowing through ammeter (A), flowing through ammeter (C). However, the meters could not respond to these rapid changes in current value, but will indicate the effective value of the current in the line and if these currents are equal, then the three ammeters will all indicate alike.

We may also take an extreme case of unbalanced load where a single-phase load is placed on phase (C), as in (B) of the diagram. Now the current in line No. 2 will be zero, but that in lines Nos. 1 and 3 will be equal and opposite in direction. Current will flow from the transformer secondaries, (A_1) and (B_1) as shown and ammeters (A) and (B) will both indicate alike. But the current from (A_1) tends to flow through ammeter (C) in the opposite direction from which the current from (B_1) tends to flow, and since both these currents are equal and opposite they neutralize each other and therefore ammeter (C) gives no reading, thus showing zero current in line No. 2.

ERNEST DICKINSON.
Kimberley, B. C., Can.

* * * *

What Causes This Motor to Spark at the Brushes?—I have a 35-hp., four-pole, shunt-wound motor that drives a fan. The armature has seventy coils, lap-wound. Under load this machine draws 280 amp. at 115 volts and has always sparked viciously. The brushes are of the Bayliss type and I find the neutral point with a voltmeter as closely as one can. When I stone the commutator down the motor runs satisfactorily for a day or so and then sparking begins and the commutator develops low bars and seems to flatten or sink.

I am wondering if this armature was designed for a four-pole machine, as it has seventy bars and coils. This number is not divisible by four without a remainder and thus throws the neutral point in the center of a bar. I shall be very grateful if some reader can explain what causes the sparking and tell me how I can overcome it.

New York, N. Y. C. E. K.

In answer to C. E. K., in the March issue, I have had similar trouble with a motor sparking at the brushes and the commutator bars sinking and becoming flat. In my case, the cause was found to be due to the fact that the motor had run hot which caused the cone of mica that wedges up the bars to loosen slightly. The bars in time loosened somewhat, thus allowing the mica to work out from between them. After a few hours running, the mica came over the bars. This was the cause of sparking.

When the commutator was stoned, it would run satisfactorily until the mica came out again, which it would do in a short time. Tightening the commutator and turning it down on the lathe cured the trouble.

Liege, Belgium. P. VAN HERK.

* * * *

In answer to the questions asked by C. E. K. in the March issue of INDUSTRIAL ENGINEER, I believe that the trouble is caused by high mica; if the commutator were undercut, this trouble would be eliminated.

Undercutting can be done with a hacksaw blade, cutting the mica down between the segments not more than 1/32 of an inch. A better way of doing this, however, is to use a three-cornered file as this leaves a V-shaped groove that is easier to clean.

Another possible cause of trouble may be a loose commutator. The commutator may be tightened by screwing up the endplate which generally has a right-hand thread. After doing this, the armature should be tested for short circuits as the insulation may be damaged when the commutator is tightened.

Maintenance Electrician, PAUL FEENEY.
General Electric Company,
Lynn, Mass.

* * * *

In reply to the question asked by C. E. K. in the March issue of INDUSTRIAL ENGINEER, his motor is carrying 23 per cent overload. If the brushes do not have enough contact area to carry the current this will cause sparking, which will gradually grow worse as the commutator blackens. The remedy is to increase the size of the brushes in width. If there is not room to do this, change the type of brush to one that has a greater carrying capacity.

Other and more serious causes of sparking are: open or short-circuited armature coils; short-circuited segments; coils grounded; sprung shaft; pulley out of true; loose bearings; commutator not true; brushes not set diametrically opposite. Low commutator bars are caused by the mica V end ring coming loose and allowing the segments to change their position. Tightening the end ring and truing the commutator in a lathe will remedy low bars.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Co.,
Springfield, Oregon.

* * * *

In the March issue C. E. K. asked why his 35-hp. motor sparks unduly. In the first place the machine is pulling about 37½ hp. An overload that is on continually is not good for any motor. A commutator will pit and blacken from several causes. For example, a ground on some other part of the motor will do this. If the mica does not wear down with the copper, the brushes will spark badly and cause black spots on the commutator. To remedy this, undercut the mica.

Vibration of the motor foundation and worn bearings are also causes. Likewise, if the commutator is worn into grooves where the brushes ride, too much end-play will cause sparking. The armature described by him is very comman in Crocker-Wheeler motors and works very satisfactorily.

Sometime ago, I had a peculiar experience with a commutator which continually blackened. We found at last that another motor on the same service from the switchboard had a grounded brush holder, but it did not spark. When this brush holder was repaired the commutator of the other motor did not blacken up any more.

Peoria, Ill. GEORGE RINGNESS.

* * * *

In regard to C. E. K.'s question in the March issue, he states that the motor runs well for a few days after the commutator has been turned. I think this shows that the trouble has been caused by hard and high mica. The mica, being harder than the copper, will not wear down at the same rate as the latter and has a tendency to keep the brushes from making good contact on the commutator; therefore sparking will result. I have found this to be a very common trouble in old-time machines.

One way to remedy this is to increase the tension on the brushes and use harder carbon. The best way, however, is to undercut the commutator; this can be done very easily with a hacksaw blade. Cut away the mica for about 1/32 in., below the surface of the copper. Readjust the tension on the brushes to 2 or 3 lb. per square inch of carbon. Have all brushes pig-tailed. I hope these suggestions will help C. E. K. to overcome his trouble.

San Francisco, Calif. P. P. SCRIBANTE.

* * * *

Answering C. E. K.'s question in the March issue, he states that a 35-hp. shunt-wound motor draws 280 amp. under full load and is a 115-volt motor. This motor is therefore working at a fair overload. I would suggest that he undercut the mica in the commutator as stoning a commutator only cuts the mica flush with the copper bars. As a rule, therefore, it serves only to stop sparking of the brushes temporarily.

I would also suggest that he sand the brushes and see that they are properly seated on the commutator. Also, I would advise him to check up on the following conditions, as possible sources of his trouble: Brushes out of line, brushes must be kept on the ¼ or ⅛ or ⅛ according to the number of field coils in the motor; worn bearings or vibration in the armature on account of the latter being out of balance.

I hope that this information will help C. E. K. to stop the sparking in his motor.

Shreveport, La. GUSTIN R. LIEBER.

In reply to the question asked by C. E. K. in the March issue, from the data given 280 amperes times 115 volts equals 32.2 kw., or 32,200 divided by 746 equals 43.16 hp. The full-load capacity of a 35 hp. motor at 115 volts is (35 × 746) divided by 115 equals 227 amp. Then 280 minus 227 equals 53 amp., or 25.5 per cent overload on the motor.

Since the motor ran satisfactorily for a few days after grinding, it proves that the armature is properly designed. In my opinion the cause of sparking is inability of the brushes to carry the current in excess of what the motor was designed for. This in turn carbonizes the surface of the mica segments, causing partial shorts in the commutator. I would suggest applying a larger motor, or decreasing the load by reducing the speed of the fan.

WILLIAM J. MILDON.
Madeira Hill Coal Mining Co.,
Philipsburg, Pa.

* * * *

In the March issue, C. E. K. describes trouble experienced with a 35-hp. shunt-wound motor. I would advise him to take out the armature, heat the commutator thoroughly and tighten it while hot; then let it cool down and try to tighten it again. Now sound the commutator with a hammer and note very carefully whether the bars move. If they do, I would advise him to make new V-rings and repeat the process of tightening. Then put the armature in a lathe, turn the commutator and undercut it.

The brushes should receive attention next. They should not cover too many bars as this will cause sparking, nor should they cover less than 1½ bars. Also check up and see that there is enough carrying capacity in the brushes. For 280 amp. there should be at least 7 sq. in. of carbon brush contact on two of the four brush studs.

Make sure that the armature is balanced, as flat spots on the pulley or unnecessary bumps in the belt lacing, or uneven air gaps will also cause sparking. NICHOLAS J. WEISS.
West New York, N. J.

* * * *

Transformer and Balancer Coil Connections—In our plant we are operating one 50-hp., one 30-hp., two 5-hp., and two 2½-hp. three-phase, 60-cycle, induction motors. The lighting load, single phase, amounts to about 10 kw. I wish some reader of INDUSTRIAL ENGINEER would give me a diagram showing how to connect three 5-kva. single-phase transformers and balancer coils to obtain 110-volt single-phase current for lighting from the 220-volt, three-phase line from our alternator. Will you also show me how to cut in on the power company's transformer in case our machine should get out of order, and how to cut out their meters and transformers both at the same time when our machine is ready to be put in service again.
Detroit, Mich. O. C. H.

Answering O. C. H. in the January issue, if you wish to keep the 220-volt, three-phase circuit balanced there is no connection that will meet your requirements. I should like, however, to offer some suggestions that may be of help. I assume that you have a 220-volt primary, 110-220-volt secondary, three-wire balancer coil. As a balancer coil is designed to take care of the unbalanced load on a 220-volt, three-wire distribution system, having a 220-volt, two-wire primary, there is no need of using three 5-kva. transformers on the lighting circuit. If it is desired to keep the 220-volt, three-phase circuit nearly balanced, I would suggest that you use two balancer coils and two 110-220-volt, three-wire lighting circuits, of 5 kw. each. Fig. 1 shows the method of connection which should be employed. If you do not wish to use the balancer coils, connect two 5-kva., single-phase transformers open delta, and run the three-phase, 110-volt circuit to your cabinet box, and divide the lighting load between phases so as to keep them as nearly balanced as possible.

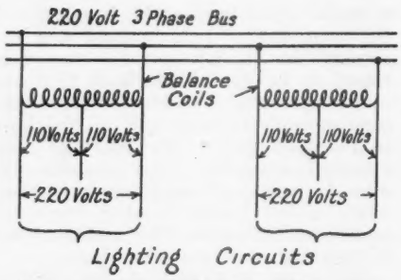


Fig. 1—Two balancer coils connected to a three-phase circuit to give two 110-220-volt, three-wire lighting circuits.

You also ask for a method of connecting the central station lines to your motor circuit in case your alternator gets out of order.

Fig. 2 shows a method of connection which I think will prove satisfactory. In proposing this method of connection I have assumed that the motors may be shut down long enough for the necessary switching to be done.

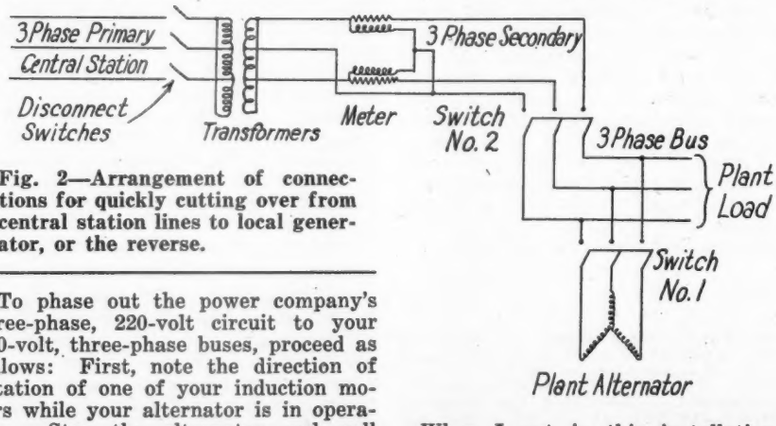


Fig. 2—Arrangement of connections for quickly cutting over from central station lines to local generator, or the reverse.

To phase out the power company's three-phase, 220-volt circuit to your 220-volt, three-phase buses, proceed as follows: First, note the direction of rotation of one of your induction motors while your alternator is in operation. Stop the alternator and pull switch No. 1 (shown in the diagram), and then throw your switchboard bus on the line by closing switch No. 2, and then disconnect switches ahead of the transformer. Start the induction motor and if it runs in the same direction as formerly your connection is correct. If the motor runs in the opposite direction, change any two of the central station leads at the bus.

Do not attempt to put your alternator back on the circuit before opening the power company's switch (switch No. 2) as the alternator is probably not synchronized with the power company's line. Then cross currents would flow between these lines and the alternator and probably cause considerable damage to the alternator or transformers or both.

If you do not want to stop your motors while changing from the power company's circuit to your alternator, or vice versa, you can install a synchroscope, synchronizing with lamps is not very reliable, and parallel the alternator with the power company's circuit in this way. When installing the synchroscope, consider the power company's circuit as an alternator. Full instructions and wiring diagrams accompany these instruments.
Galesburg, Ill. EARL BABER.

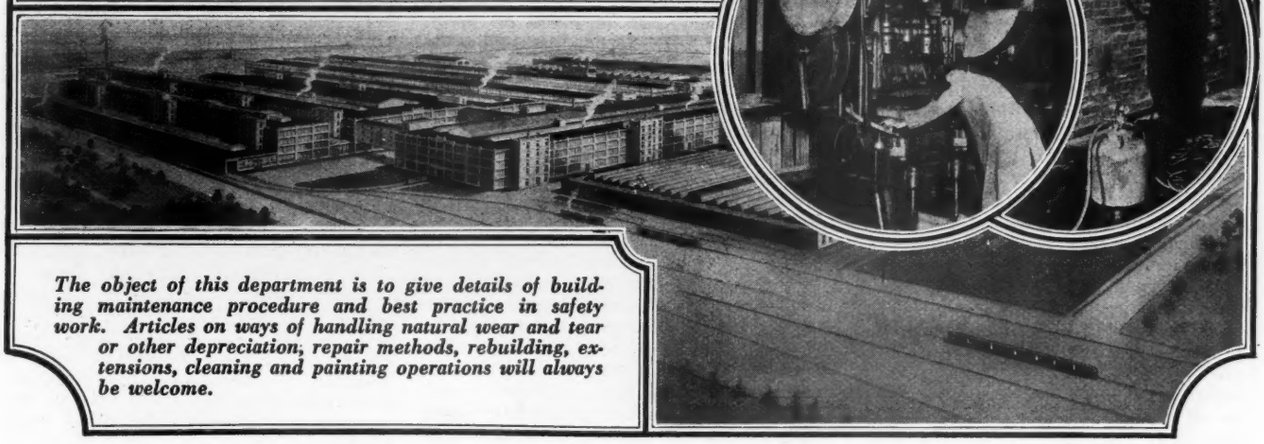
* * * *

I have noted the question by O. C. H. in the January issue, and want to say that his proposal to connect three 5-kva. transformers in the manner indicated, is not practicable. I suggest that he use two 220-volt, auto-transformers with 50 per cent taps to obtain a single-phase, three-wire, 110-220-volt lighting system. The transformers should be of 7½-kva. capacity each and connected open delta.

I recently wired a plant which generates its own power but is arranged to use central station power in case of emergency. The central station lines come in through the usual service switch and meter and were connected through a single-throw, fused switch to the three-phase bus on the plant switchboard. When this switch is opened it disconnects the power company's transformers and meters. It is only a matter of a moment, however, to open the plant generator switch and close the switch between the switchboard and the central station lines and thus operate the plant on central station power when necessary.

When I put in this installation I had, of course, to phase out the incoming power lines with the plant generator, which I did simply by testing one of the three-phase motors for rotation, first, when operating from the plant generator and then when cut in on the power company's line. On the first trial, the motor when operated on central station power rotated in the opposite direction to its usual rotation; then I transposed two of the incoming power lines and, on a second trial, the motor rotated in the proper direction.
Chicago, Ill. A. NOEPPEL.

Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

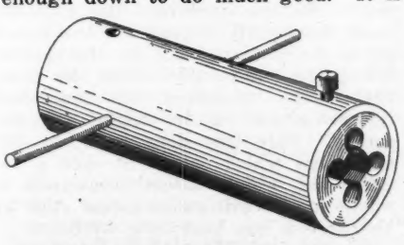
Simple Diestock Facilitates Rethreading of U-Clips

THE ever-increasing use of steel structures often brings the maintenance crew face to face with a new problem. In particular, shaft hangers, pipe lines, conduits, and a variety of interior fittings must be attached to steel shapes, and the methods of attachment differ widely from those employed in mill-construction buildings.

One of the commonest methods of attaching parts to structural steel, for permanent installations as well as for temporary set-ups, is by the use of U-shaped clips. The cost of such clips is low and they are so widely used that they can be made up in quantity and kept in the stockroom.

The only serious objection to U-clips comes from the men on the firing line —the men who have to take off existing clips, or put up others that have already been used. The men complain that the threads on the ends get battered up, particularly the threads extending beyond the nuts. To get a nut off over these damaged threads, or to start one on such an end, is not only vexatious and wasteful of time but it frequently results in spoiling the thread in the nut or clip.

With ordinary bolts, bruised threads may be chased over with a die in short order, but with clip threads, the presence of the other leg, full length, effectually prevents turning the die stock around—or at least turning it far enough down to do much good. It is customary to take such clips to the blacksmith and have them partially straightened out; then they go back to the shop for rethreading and finally make another trip to the blacksmith for forging to the original shape. All master mechanics know of the loss in connection with this process.



With a diestock like this U-clips and stud bolts can be rethreaded without difficulty.

The simple diestock shown in the illustration can be made in the shop and will enable the task of rethreading clips to be done as quickly as similar work upon an ordinary bolt. As will be seen this diestock may be made from a piece of pipe or steel tubing, or it can be cut from a solid round piece. The valuable feature is in the extended body which places the die ahead of the handle by whatever amount is desired. The body should have a smaller inside diameter than the die in order that a recess can be bored out to fit the die and a shoulder cut for it to rest against.

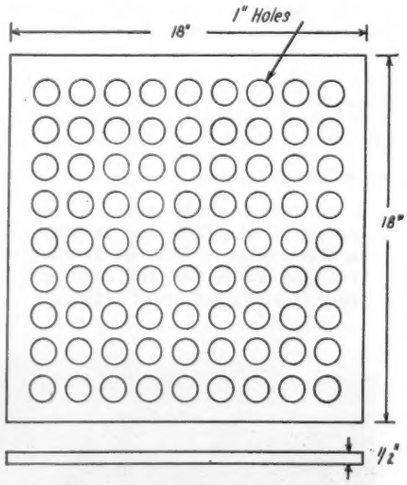
A simple setscrew retains the die in position, its point dropping into the countersink provided for the purpose. For a handle a steel rod or a piece of pipe is inserted crosswise. As rethreading requires much less power than threading for the first time such a diestock need not be made as strong as the conventional ones and gratifying lightness results. This is a valuable feature because the stock may be used by workmen on a ladder or scaffold, where it is thus possible to rethread a clip without taking it down.

The class of work in the plant will determine how much offset the die should have, when making up such a stock. Because it is much easier to start a thread on a new blank when the die itself lies practically in the plane swept by the handles, the ordinary stock is made in that way—and that is the most satisfactory form for general work. However, occasions such as mentioned above do arise when considerable offset is desirable. Other uses will be found for this tool, among them rethreading cylinder studs without removing them. DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Repairing and Maintaining Worn Concrete Floors

OFTEN where concrete floors are subject to heavy trucking, the life of the floor is short. As the concrete usually wears in spots or in grooves, it makes for hard trucking. Our experience has given us the following methods of making repairs which we think are probably the best ways of prolonging the life of our factory floors.

When laying a new floor which we know will receive severe service, or where an old one has worn so much as to require entire resurfacing, we insert cast-iron slabs, as shown in the accompanying sketch. These slabs are 18 in. x 18 in. x ½ in., and perforated with 1-in. holes. With a simple pattern any plant with its own foundry can make them up at little expense. These cast-iron slabs are placed on the rough



Details of cast-iron plate to take the wear on concrete floors.

When new concrete floors are laid or old ones receive extensive repair and resurfacing, it often pays to add cast-iron floor plates such as this in trucking aisles where it is known that they will receive excessive wear. The pattern for such a plate is easily made and the plates may be cast at small expense.

floor before the finishing coat is applied and the finishing coat poured over and flush with the slabs. Enough of these slabs should be laid side by side so as to be over the width of the trucking aisle. A floor thus treated, we have found, will out-wear five ordinary floors.

In cases where a floor is badly worn and the expense of the above method is not warranted, a special mixture may be applied to the whole surface. This mixture consists of pitch, powdered asphalt and sand in the proportion of 1 to 17 to 18.5, respectively. This must be mixed quickly and applied while hot, as it sets rapidly. In order to give entire satisfaction, the mixture should be applied at least 1½ in. thick.

In cases where a floor is pitted in spots but is othewise in fairly good repair, the above mixture may be applied with good results if the surface to be treated is heated to a high temperature before the mixture is applied. One of the best ways of applying this heat is under pressure, as with an oil burner.

Electrical Engineer, H. E. STAFFORD.
Port Arthur, Ont., Can.

Adding Dump Body to Old Electric Tractor Rebuilt for Hauling Coal

SOME time ago we needed a small truck to haul coal to four annealing furnaces and it was decided to rebuild an old tractor which had for several years been used for hauling pig iron in the foundry. This tractor was strongly built and had given very satisfactory service. An examination showed that it was in such good condition that only minor repairs would be needed to fit it for the new service. These repairs consisted mostly in putting new rubber tires on the wheels and installing a new and larger battery.

The battery contains twenty Edison cells A6 size, 45-amp. rating, arranged in four trays of five cells each. A standard 24-volt motor fitted with ball bearings drives the truck. The connections to the battery and between the upper and lower trays are made with the Edison tray end terminal lugs. The cells are arranged ten below and ten above. The battery is exchanged early every morning for another one charged during the night. It cannot be charged on the truck because sand and refuse are hauled during the night and coal during the day; also the battery must be removed to allow the cells to be watered. A change of battery can be made in ten minutes.

The battery box is made of ⅛-in. steel plates with both ends removable by sliding them upwards. A steel partition in the middle supports the upper section of the battery. The battery box has a steel cover.

Also, some changes were made in the wiring which is now flexible, standard No. 6 oiled cambric with heavy braid, carried to the motor and switch in 1¼-in, rigid conduit tightly strapped along the inside of the frame. At the motor the six leads, two armature and four field leads, are terminated with copper lugs so that the motor may be readily removed for repairs. The leads enter the motor through watertight rubber bushings. All wiring connections are made extremely tight either with set screws or bolted lugs because of the heavy flow of current. All conductors running in parallel and exposed to the weather are tape covered and coated with asphaltum paint.

The most important alteration was fitting a steel dump body to the truck. This was made in the form of a strong steel box 4 ft. 6 in. long, 3 ft. 3 in. wide and 2 ft. 6 in. deep, reinforced along the upper edges and around the middle with angle iron. The front end of the body rests on a 2-in. pipe bearing which allows the body to be tipped for quickly unloading the coal by opening the front end which is hinged at the top. The rear end of the body is raised by a chain and hand windlass at the back end of the truck. The construction of the body and windlass is clearly shown in the accompanying illustration.

The truck as rebuilt weighs 2,600 lbs. unloaded. It has a capacity of 1¼ tons of coal and with this load it travels at the rate of 180 ft. per min. on the level. With an operator and a helper the truck has for some time hauled an average of 20 tons of coal, enough for four annealing furnaces, each working day.

H. S. RICH.
New Britain, Conn.

A steel dump body raised at the end by a windlass was mounted on the tractor to fit it for hauling coal during the day and sand and other foundry refuse at night.

Novel Method of Painting Fire Houses Increases Their Visibility

TO AID in finding fire-fighting apparatus at twilight, or at night, one large plant has painted all shelters housing fire apparatus with red paint. A horizontal white band about 12 in. wide is painted around the center of the shelter. This is done to all shelters, shanties, outhouses or other small structures containing fire hose, chemical wagons or other industrial fire-fighting apparatus. Sand boxes and fire buckets are similarly painted. All fire hydrants are painted red with a white cap on the top.

It will be found that the visibility of these structures is greatly increased by this method of painting. Even in daylight this arrangement of color makes the location of the structure very conspicuous in the plant yard which, of course, is exactly what is desired. The greatest value, of course, is at night when the white spot is very conspicuous against the dark background.

Chicago, Ill. H. H.

How to Prevent Low Spots When Repairing Concrete Floors

IN OUR machine shop there was a good 6-in. concrete floor. When the floor was put down, about fifteen years before, it had been laid in 8-ft. sections across the shop. In the course of time these sections had separated slightly but not at all objectionably, except where the passing of trucks had chipped the edges of the sections in the aisles.

As our floor trucks carried loads up to one ton and were constantly moving, these innocent sections became gulleys that the wheels traversed with a bump —a bump that was risky for cast-iron wheels and that added considerably to the labor of moving the trucks about by hand.

As the corners were getting rounded further and further back, we decided on a repair. Now that the repairs have stood for two years, it is possible to speak of the results with the confidence of experience.

Where these gulleys were worn, we cut out the concrete to a depth of 2 in. or more, running the cut back to take out all of the round corner no matter if it did make a wider groove in some places than in others. The work was done in relays, doing so much on a Saturday morning and filling up with concrete that then had a chance to harden by Monday morning.

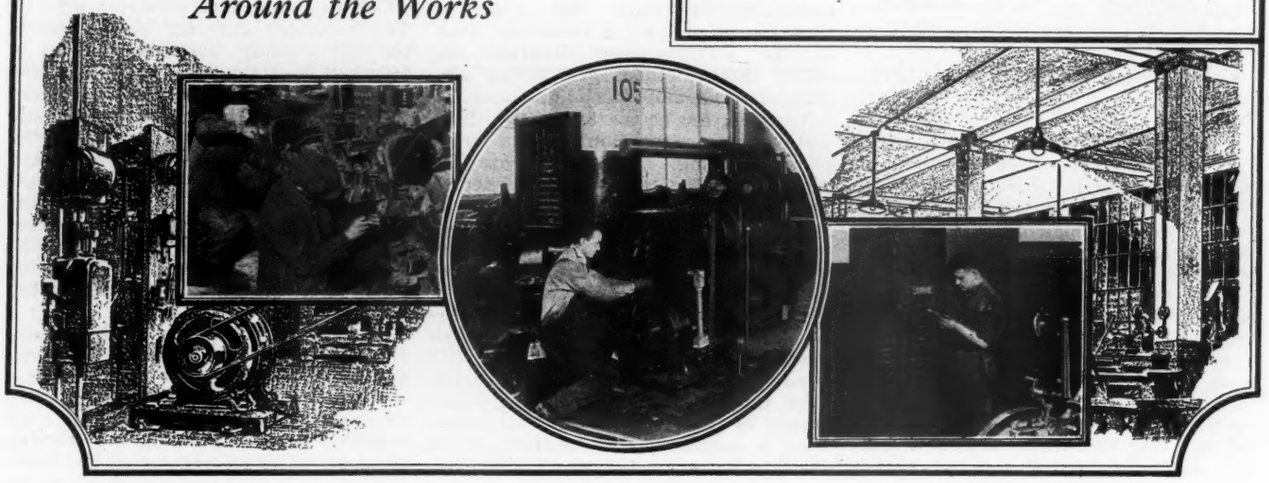
A sand-and-cement concrete was used. Before applying, the cut-outs were thoroughly wetted and the water given a chance to soak in. Instead of filling the cut up flush with the floor, they were trowelled off somewhat higher—about ¼ in. higher in the center. This was done to offset the shrinkage which occurs at such a repair and which unless allowance is made for it, will cause a low spot by the time it has been in a while.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Operating 220-Volt Sand Cutter on 440-110-Volt System

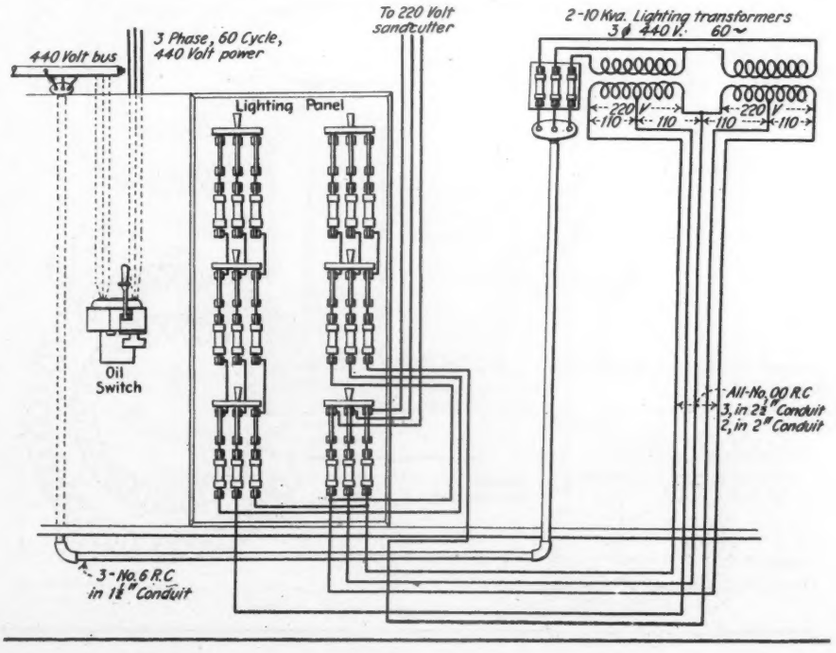
IN A PLANT where the 13,000-volt, 60-cycle, three-phase incoming power is stepped down to 440 volts through three 150-kw. transformers, the lighting system is supplied by two 10-kw. transformers which step the 440-volt power down to 110 volts. A problem which had to be met some time ago was the operation of a 220-volt sand cutter, the only motor of this voltage in the plant. The lighting transformers were so connected as to give 220 volts, three-phase, on three terminals of the secondary and 110 volts on all five terminals.

As a solution of the problem the three-phase, 440-volt power busbars at the switchboard were tapped off to the primary of the lighting transformers and protected by three fuses. The secondaries were connected in series and five equally-spaced leads were brought out. These are No. 00 rubber-covered conductors in conduit. The primary leads are three No. 6 rubber-covered conductors, also in conduit.

At the lighting switch panel, one 3-pole switch was disconnected from the busbars and to this switch the 220-volt, three-phase leads from the transformer were connected for operating the sand cutter, which is driven by a 7½-hp. motor.

The 110-volt leads are connected to the other five switches. As the sand cutter has a balanced load it causes no trouble except a slight flickering of the lamps at times, but as it is run only during the late night hours this does not matter. One-half of the total lighting load is carried by two switches and the other half by the remaining three switches in order to balance it as nearly as possible.

New Britain, Conn. H. S. RICH.


To 220 Volt sand cutter
2-10 Kva. Lighting transformers 3ϕ 440 V. 60~
3 Phase, 60 Cycle, 440 Volt power
440 Volt bus
Lighting Panel
220 V
110
Oil Switch
All-No. 00 R.C 3, in 2½" Conduit 2, in 2" Conduit
3-No. 6 R.C in 1½" Conduit

The secondaries of the 440-110-volt lighting transformers were connected in series to give 110-volts on all five terminals and 220 volts on three terminals, from which leads were run to the sand cutter through a three-pole switch on the lighting panel.

How to Restore Service Quickly After Fuse Blows

ON PAGE 605 of the December issue of INDUSTRIAL ENGINEER Donald L. Hoare described how he uses a double-throw switch with two fuse blocks for restoring power service when a fuse blows. This scheme is practicable, of course, but it should be noted that when fuses blow there is usually a reason and the trouble should be corrected. Offhand, one should not run to the double-throw switch immediately and throw it over on to the other set of fuses because this extra set will, in most cases, also blow. Such practice not only causes a waste of fuses but should be discouraged altogether, as liable to cause damage to electrical equipment. This extra "shot of juice" to a machine which is slightly damaged and which could probably have been easily repaired may make matters worse instead of better. Surely, the rule of "a stitch in time" applies to electrical equipment.

As another example of bad practice, I have seen electricians throw in the switch of a motor momentarily after it had failed. In this way they thought it was easier to locate the trouble, for the motor would spit fire at the fault. I have also seen other faults develop when a switch is thrown in this way several times. If the troubleman threw the switch in in this way only once, perhaps no serious results would follow, but usually he does not locate the exact spot of the trouble the first

time and so keeps on repeating the process until he does locate it. By that time, serious damage may have been done. I have always been against this practice and I should like to know what other readers of INDUSTRIAL ENGINEER think of it.

Oakland, Calif. S. H. SAMUELS.

How Single-Phase Fan Motors Are Started

THE function of the starting winding on single-phase fan motors, and the manner in which this function is discharged, is sometimes not clearly understood by repairmen. A description of the different types of fan-motor windings may, therefore, be of interest.

The three-phase induction motor is self-starting because of the revolving magnetic field resulting from the proper arrangement in the stator of coils which receive currents that are out of phase with each other. The single-phase motor is not inherently self-starting because it lacks a revolving magnetic field, due to its having a power supply from one phase only. Practically all alternating-current fan motors are of the induction type and are operated from a single-phase supply. To make these fan motors self-starting, recourse is had to split-phase windings and combinations of reactance and resistance. The action of these is to produce a revolving field. In the accompanying diagram are shown three methods of starting single-phase fan motors.

The diagram at the top of the illustration shows a fan motor with a three-phase winding. The parts of this winding, (A), (B) and (C) are connected together at a common point. They are spaced one-third of the pole spacing between centers of the poles of each winding. The (A) winding is connected directly to one side of the power supply; the (B) winding is connected to the reactance or choke coil which is situated in the base of the fan; and the (C) winding is connected through a resistance to the same side of the power supply as the (B) winding. This resistance is usually placed in the base of the fan. In some cases, the (C) winding is wound with small wire and a large number of turns to increase its resistance, and thereby do away with the need of the external resistance. Due to the reactance in series with the (B) winding, the current through it lags behind the current in the (C) winding which has resistance in series with it. The combined currents pass through the (A) winding; hence the current in (C) will lead the current in (A) and the current in (A) will lead the current in (B). This gives an approximate three-phase condition with a revolving magnetic field and the motor will start.

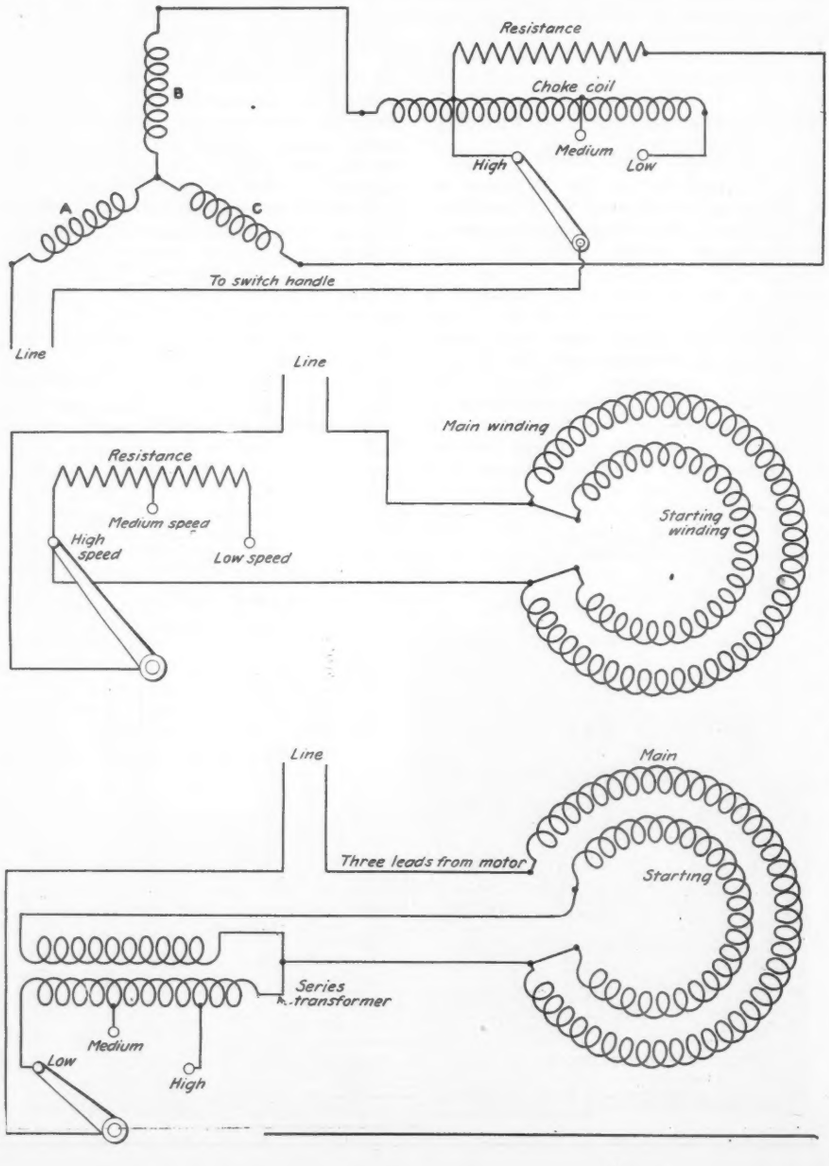
Speed regulation is obtained by cutting in more turns in the coil by means of the switch shown. Cutting in extra turns lowers the voltage applied to the winding, thus lowering the current and flux, increasing the slip and decreasing the speed.

The motor described above has essentially a three-phase winding—the motor shown in the middle diagram has a distributed-type winding, which is in two parts. One part is called the main winding and the other is the starting winding. The pole center of the starting winding is placed one-third of the pole spacing from the center of the pole of the main winding and overlaps the next pole of the main winding. The resistance of the starting winding is greater than that of the main winding; however, the main winding has the larger number of turns, hence, its reactance is greater. The two windings are connected in parallel; hence, when voltage is impressed on them, the current in the main winding will lag behind the current in the starting winding and the flux from the main winding will lag behind that of the starting winding. This produces an approximate two-phase condition with a revolving field and the motor will start.

To vary the speed, either resistance or a choke coil can be used in series with the winding; the added resistance or reactance decreases the voltage, which decreases the current and flux in the field, thus lowering the speed. Resistance in two steps giving three speeds is usually employed.

The latest type of fan winding is shown in the bottom diagram. There are two windings in this motor, a main winding and a starting winding, which are displaced 90 deg. In the base of the motor is a series transformer, the primary of which is connected in series with the main winding of the motor. The secondary winding of the series transformer is connected across the starting winding of the motor. Since the current induced in the secondary winding of the transformer lags behind the current in the primary, the current in the starting winding will lag behind that in the main winding, thus producing a two-phase effect, which starts the motor.

To increase the speed of the fan,



Three types of fan-motor windings in common use.

In the top diagram is shown a three-phase winding energized from a single-phase supply through a combination of resistance and reactance. In the middle diagram is a distributed type winding. The bottom diagram shows a somewhat similar winding with which a series transformer is used for starting.

turns are cut out of the primary winding of the transformer, thus decreasing the reactance in series with the main winding, and increasing the flux density.

The iron in the transformer is worked at a high density; hence the change in number of turns in the primary winding together with the change in primary current, has the combined effect of keeping the secondary voltage approximately constant. Consequently, a high starting torque at low speed is obtained.

The advantages of this type of winding are: greater speed range, reduction of power input with reduction of speed, high starting torque and a quiet running motor on single-phase, due to the distributed type of winding.

Detroit, Michigan. A. C. ROE.

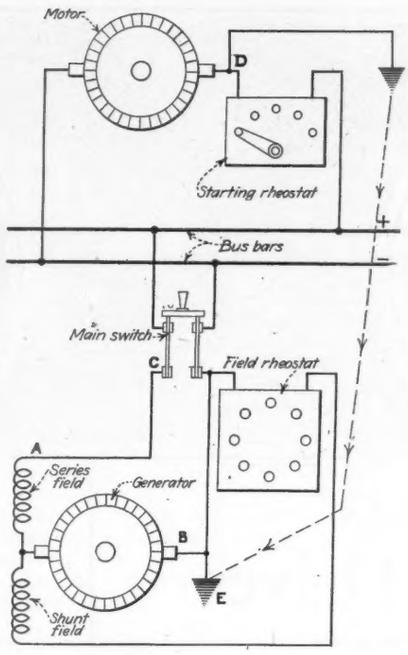
A Combination of Two Unusual Grounds Caused Shutdown of Generator

A PECULIAR failure occurred on a 110-volt, compound-wound, direct-current generator which supplies light and power for a small manufacturing plant. The failure occurred while the generator was running at full speed and while one of the largest motors in the plant was being started. The instant the arm of the motor-starting rheostat was pressed against the contact button, the pointer of the switchboard ammeter first indicated an excessive surge of current and then swung back to zero. It was apparent that the generator circuit had opened.

It was at first supposed that the difficulty was due to an opening in the series-field circuit. But when an incandescent lamp was connected between the series-field terminal and the negative brush terminal, at (A) and (B) in the diagram, the lamp glowed at full brilliancy, showing that the generator was delivering full voltage at this point.

It was then thought that the trouble might be due to a loose connection in the lead from the generator to the bus. When the connections were examined, it was found that the solder had melted out of the terminal which connects the positive lead of the generator to the main switch, shown at (B) in the diagram. This, of course, indicated overheating, which could occur only by the passage of an excessive current. It was evident that the heavy surge of current when the motor was being started had caused the cable to buckle and withdraw slightly from contact with the socket, thus opening the circuit from the generator.

The investigation was continued so as to locate the fault that caused the heavy flow of current. A ground was found on one of the motor leads, as indicated at (D) in the diagram. This ground was caused by the positive lead of the motor coming in contact with a water pipe.



A combination of grounds shut down the generator shown in this diagram.

One ground occurred on the positive side of the motor. The negative side of the generator came in contact with the insulated generator frame. The accompanying illustration of the generator shows how the insulated generator frame was grounded through the outflow pipe. These two grounds made a short circuit across the generator.

This discovery made the trouble appear more mysterious because the ground current must have a path back to the generator, and as the generator frame was mounted on insulation, the generator was considered as being insulated from the foundation.

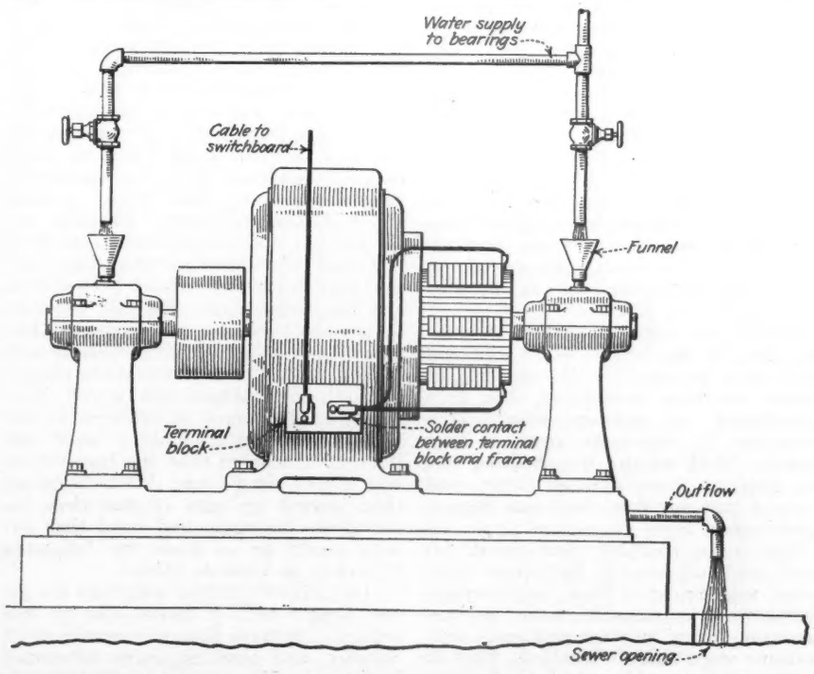
Further investigation disclosed that at the point where the lead from the negative brushes is connected to the terminal block, some repair work had been done during the preceding night, a part of which consisted in resoldering the connection. Owing to carelessness in doing the job, some of the solder had flowed down and made perfect metallic contact between the terminal block and the frame.

This accounted for a ground on the positive side of the line and for a connection to the generator frame from the negative side of the line. How the current passed from ground to the supposedly insulated generator frame was not seen until we remembered that the generator bearings were water-cooled as shown in the accompanying illustration of the generator mounting at the bottom of the page.

Although the generator bedplate had insulation beneath it, there was a path to ground through the overflow pipe shown at the bottom and at the right of the illustration, through the water to the sewer and to ground. This made a short circuit across the bus as indicated by the dotted line in the diagram. The short circuit traveled from the positive bus to the starting rheostat of the motor, to the positive lead of the motor, then to ground at (D), through the ground indicated by the dotted line to (E), and then to the negative lead of the generator, which is equivalent to the negative side of the line.

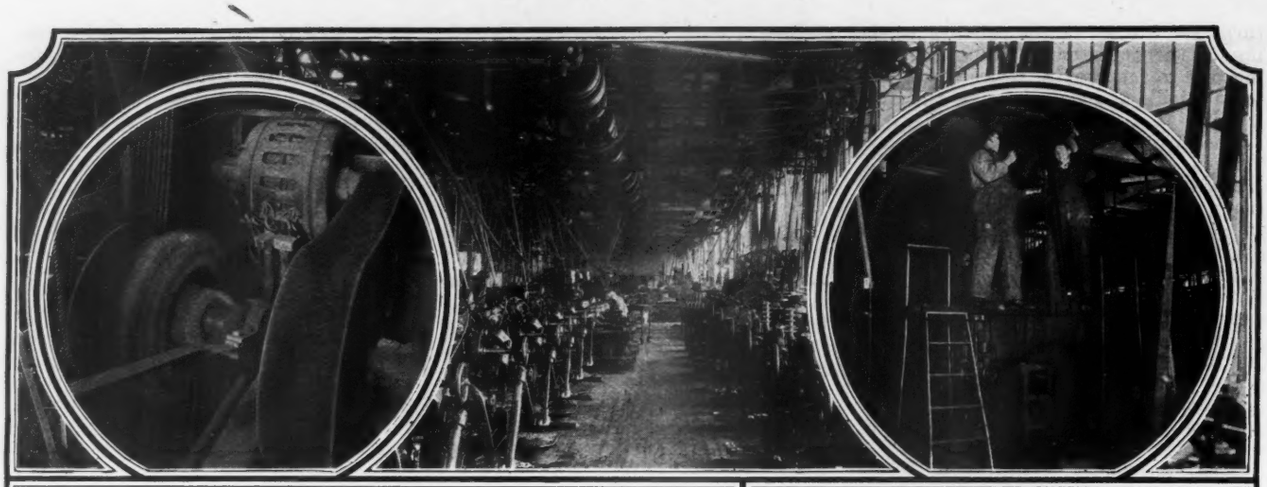
It is very probable that the resistance encountered by the ground current in passing through the water gap between the outflow of the bearing jacket and the sewer opening is all that prevented a disastrous burnout somewhere in the system which would have shut down the plant.

St. Louis, Mo. A. J. DIXON.



The bedplate of this generator is insulated from the cement foundation.

The generator was considered to be insulated from ground until it was discovered that current could flow from the bedplate through the outflow pipe, in the lower right-hand part of the illustration, through the water to the sewer and to ground.



Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Simplifying the Installation of Ball Bearings on Main Lineshafts

THERE were two 120-ft. lines of 2¼-in. shafting in our machine shop, driven by a 20-hp. Westinghouse motor that was installed in 1904. The motor operated at 1100 r.p.m. which was stepped down to 140 r.p.m. on both lineshafts through belts to one jackshaft. The parallel lines of main shafts were connected (as was the motor drive) by 8 in. two-ply Schieren belting. When the installation was made, there were less than twenty-five machine tools in the shop; at the time of which I write, there were sixty-seven that were driven by this motor. Although the machines were not all run at once there were times when a large number of them were in operation. Among them were four planers, five screw machines up to 1 in., twenty No. 7 Becker millers, and other tools of related capacity.

The machinery was not all added at once and the increased power demand might have passed unnoticed, save for the necessity of changing 40 amp. fuses to 60 amp. and the frequent burning out of these. It was the electrical end of the situation that gave us the idea of a mechanical change.

We got the habit of reading the meter, first in checking up our bills and then as a measure of the amount of power we were consuming. We thus established our average hourly consumption in kilowatts over a long period. Then we ran the shafting idle for half an hour and an hour, and learned that our dead load was disproportionately high.

The main shafting was tried for level and alignment, but very little error was found. Then the countershafts were inspected to detect any unnecessary drag in them and some corrections were made. Machines that we were certain would not be used again for a month had their belts shifted off the mainshaft pulleys and the loop supported upon belt perches.

But these savings in power were small, as had been expected and we passed on to a ball-bearing installation as the real solution of the problem. Our main shaft lines ran in babbitted bearing hangers of Dodge make; the countershafts were the usual heterogeneous collection from machine tool builders and sundry makers of equipment.

We selected bearings that would go in our present hangers; these bearings are of the double-row type with one row of balls on each side of the hanger, slung in a casing held between pivoting setscrews. The bearings are clamped to the shaft by split sleeves.

For the countershafts, we put ball bearings only in those where the speed was excessive or the belt tension high. The installation of bearings of any type in a countershaft is of little interest, and this case was no exception.

But the installation of main shaft bearings involves a good deal of work because shafting must be uncoupled and lowered to the floor, pulleys stripped, and so forth. Frankly, we did not like the idea of doing this work and told the salesman that this was the one thing that stood between us and the dotted line. He said the cost to us would not be excessive, as they would send an expert from the factory to help and direct at no extra charge and all the expense we would have would be the wages of two men on one Sunday, for after looking over our lines he concluded that the installation was a very simple job. We believed all this, signed up, and in due time received the bearings and word that our man would be on hand the following Saturday to arrange things.

Our private opinion was that the job was bigger than it looked and we had arranged to have four of our men work Sunday, and that Saturday afternoon if wanted. We suggested the latter to the factory expert and he agreed, although he said it was not necessary and assured us that all would be running finely Monday morning.

On Monday morning the shop was in a sickening plight. Belts off everywhere, pulley halves scattered about the floor, nicely piled material knocked galley-west, dirt and litter over all. And what was worse, there were only eight out of twenty-eight bearings in their hangers. Our expert had skipped town, with word that he would be back next week.

It took us all the morning to get straightened out and ready to go to work in the afternoon. It might be added that the factory expert failed to show up the following week and through this failure we came in contact with the job of installing most of the bearings.

In attacking the job ourselves, we decided that it was wholly unnecessary to lower the shafts to the floor; also, that no pulleys need be removed, save those which interfered with the bearings in sliding them to position, and that no belts needed to be unhooked. As most of the belts had been installed and were running satisfactorily before we had a belt lacing machine, the task of unfastening these and connecting them up again was no small item—this item we intended to eliminate.

Our method was to provide a resting place for each length of shafting as it was taken out, right up in the air alongside its regular position. As the ball bearings were much larger where the case surrounded the balls than the space inside the hangers, it was necessary to get the shafts out of the hangers in order to slide the bearings in position, and then put the assembled job back, dropping the concave part of the casing over the pivotal set screw of the hanger. In this case the hangers were of the side outlet type, the gap in the hanger frame casting being closed by two links bolted on.

The accompanying illustration shows

the rests we made up. A side view of the rest in place on a post underneath the shafting is shown at (A); (B) is a sectional view from above. As will be seen they are extremely simple and cheap to make—and they proved equally efficient. The building construction included 8-in. by 8-in. oak posts set on 8-ft. centers and the overhead beams rested on these posts. The hangers were suspended from the beams, and the center line of the shaft was 15 in. out from the posts. The hangers had been erected with their opening side toward the posts—this was a little more convenient for us, but our scheme would have worked had the hangers been reversed.

The rests we made were U-shaped pieces of flat steel. They were sized at the open end to fit the posts, and the loop ends were made long enough and of such width that they extended several inches beyond the shaft and would admit the new bearings, which were somewhat longer than the plain ones which we were taking out. Three of these rests were made up and were amply sufficient for the job, as the shafting was in 20-ft. lengths.

In use, one of the bolts was taken out of the open end, so the rest could be put around the post. The bolt was then inserted, the rest shoved up against the under side of the shaft and both bolts securely tightened. These rests not only served to support the shafts as we took them out but they were a very close guide in re-aligning the shaft vertically when it came to adjusting the hanger screws to the new boxes.

The loop end was also very useful in lifting the shaft out of the hanger pocket. Standing on horses or ladders, it is neither easy nor safe for men to juggle 200-lb. pieces of shafting, as the crew who had worked with the factory expert were quite willing to testify. With these rests, a small bar was used to pry the shaft up and out; in replacing the shafts, the same procedure was followed. The application of the bar is shown by dotted lines on the drawing.

With the shaft lengths laid out on the rests, it was a short job to get off the couplings and slide on the bearings. What pulleys had to be removed, were taken off first and these were not replaced until the lengths were coupled up again.

The free end of the shaft was aligned with the opposite end (the end which was coupled up) and then the center was brought up. Then the rests were taken off and moved to the next length. While some of the men were placing the rests in position, others were adjusting the top setscrews of the hangers and applying pulleys and belts to the length just assembled. In this way, the shafting was all ready for business by the time the section ahead was well under alteration.

This method was so successful that the man-time per bearing installed was less than one-third of what it was for the few that were installed by the factory representative. The absurdity of lifting out and lowering heavy pieces of shafting with bulky pulleys on them cannot fail to be apparent—the labor involved is exceeded only by that required to raise the shafts back again. Yet countless instances of shafts lowered are recorded. Sometimes tackles and hoists are employed; after much work to secure the necessary headroom, these can often be used and they do save labor but the risk is increased, as witness the accidents resulting from shafts tipping and sliding out of their slings when, say, ten or twelve feet in the air.

Rests or supports are very easily made. They save their cost a dozen times over, on even a small job. Those made up for the job described above were retained in the stock room and have been of occasional use since. Also the same idea has been applied in other locations. In this case, the proximity of the posts suggested the design. In another location about the plant, a ball-bearing installation was made where the hangers were bolted to steel beams and here U-shaped pieces were forged up with a 10-in. flat section at the bottom and with clamping pieces at the top to fit the beam. This was used as a stirrup to support the shaft while making the change to ball bearings.

As to the results obtained from the use of ball bearings on our lineshafts, I have no record of the saving of power, in kilowatts, but I recall that there was a most noticeable difference in the bills and I do know that soon after they were installed we began to hook on machine after machine and it did not bother the already theoretically overloaded motor a bit.

Out of the ball bearings installed I have had one set go bad in about ten years. That was returned without local investigation and a service charge made for the repairs. That is the only expense we have been to in the matter of shaft bearings. They are oiled every six months.

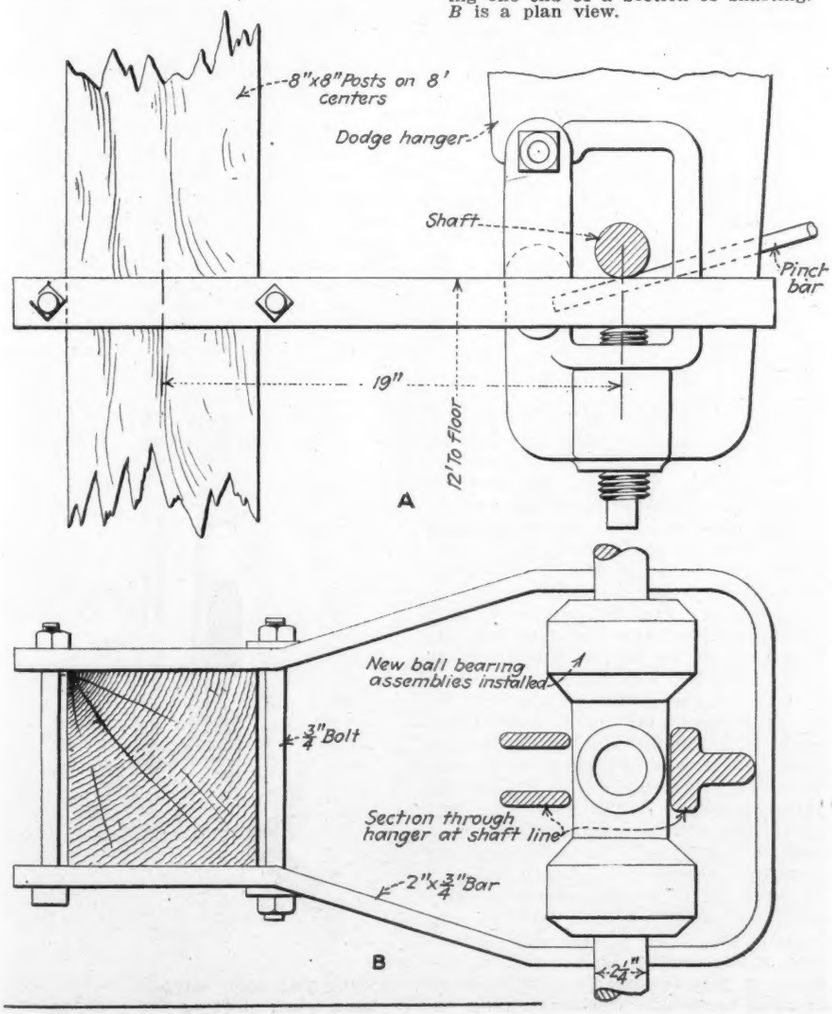
For that matter, the Dodge babitted bearings never cost a cent for maintenance in an even longer period. They were oiled every four weeks.

I should say that the change we made is worth while for anyone. I put ball or roller bearings in machinery wherever I can, to cut the inevitable renewal expense, if for no other reason. It is interesting to note that these shafts run for thirty-eight seconds after the switch is opened—just time a shaft with plain bearings for comparison.

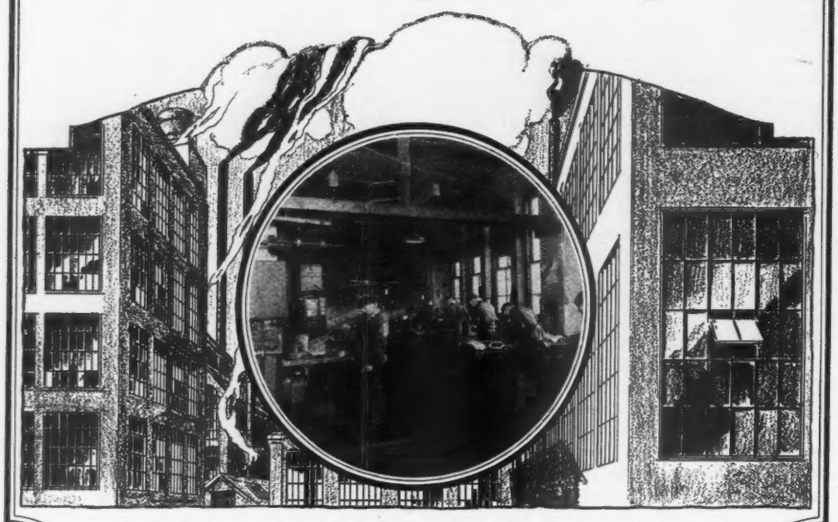
DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

With a simple rest like this it is not necessary to take shafting down when ball bearings are installed.

At *A* is shown a side view of the rest fastened to a post and supporting one end of a section of shafting. *B* is a plan view.



In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

An Easy Method of Moving Armatures Around the Shop

MANY small repair shops do not have an overhead traveling crane to move armatures around the shop. In the electric repair shop of our plant we have a small chain block in the center of the room, which we use to take apart the motors brought in for repairs. When the armature is lifted out by the chain block, the wooden wheels, shown in the illustration, are placed on the ends of the armature shaft. These keep the armature off the floor, thus keeping the winding from being rolled in the dirt and steel cuttings on the floor. Also, it affords a very convenient means of moving the armature around the shop. The armature can be very easily rolled to any desired spot, and it can be moved in very cramped quarters. By turning one wheel one way and the other wheel the other way, the armature can be turned end for end in a very small space.

The wheels are made from 2-in. planks and are about 4-in. larger in diameter than the armature on which they are to be placed. Two circular pieces are nailed together with the grain of one at right angles to the grain of the other. Then a hole, a little larger than the armature shaft, is drilled in the center of the wheel. Although a large wheel will fit most of the smaller armatures, it will be found more satisfactory to have several sizes of wheels, particularly if the range of armature sizes handled in the shop is very great.

O. C. CALLOW.
Chief Electrician,
Trumbull Cliffs Furnace Company,
Warren, Ohio.

Wooden wheels placed on the end of the motor shaft afford a convenient means of moving an armature around the shop when no overhead crane service is available.

Two Simple Methods of Counting Coil Turns During Winding

IT IS usually necessary to know the number of turns being wound in a coil. I will describe two methods which I have used successfully and the reader may pick the one most easily adapted to his conditions.

The simplest means of counting turns is by using the ordinary revolution counter. For this purpose a tight-fitting wooden plug is driven into the outer end of the hollow spindle of the lathe used for winding. A small hole is made in the center of the plug and the "business end" of the revolution counter is fitted snugly in the hole so that the revolution counter is supported by this end in the axis of the lathe spindle. If the gears are well lubricated with sewing machine oil, it will be found that the weight of the counting mechanism is quite sufficient to cause the revolution counter to hang vertically, even at high lathe speeds. Now if the screw in the center of the dial of the counter is loosened so that there is just enough friction to cause the dial to revolve without slipping, the dial may be easily reset with the finger after a coil is wound. This will make it unnecessary to run the lathe to reset the dial to zero.

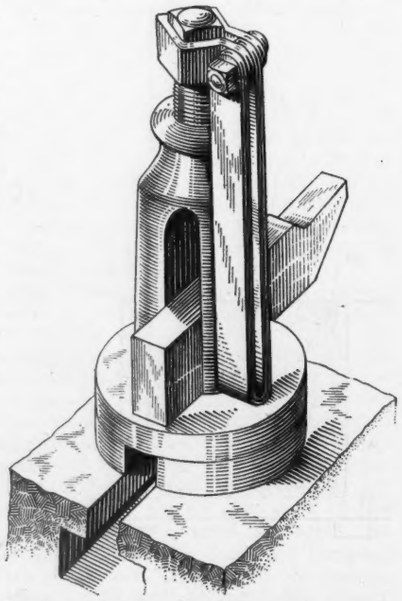
The second method of counting coil turns is by the use of the recording counter of an ordinary electric meter. A plug of wood is fitted into the hollow spindle in the manner described above, but instead of drilling a hole a staple is driven into the outside end of the plug. The unit hand of the recording counter is removed and a small loop of No. 18 copper wire is soldered to the stem. The recorder is mounted at right angles to the lathe spindle, with the shaft of the recorder parallel to the spindle axis and as close to the spindle as it can conveniently be placed. The recorder may be fastened to the wall, to a bracket from the wall, or to a bracket from the back of the lathe. A No. 12 wire is connected at one end to the staple on the spindle plug by means of a small loop. The other end is connected to the loop on the first stem of the recorder. This arrangement makes a drive with two universal couplings, hence it is not necessary that the apparatus be exactly in line.

Readings may be taken in the usual manner, by subtracting the original reading from that obtained after the coil is wound, although it is best to determine the final reading beforehand and when the hands come to this reading you will know that the coil is completely wound.

S. H. SAMUELS.
Oakland, Calif.

Handy Tool-Post Wrench Which Stays On the Post

THE lathe tool post is a source of delay when it comes to shifting the tool position between cuts. Time is consumed in stooping to pick up the wrench, placing it on the tool post and removing it before starting the cut. This time can be saved through the adoption of a special wrench which was devised by one mechanic. In this wrench, which is illustrated here, the handle is made to swivel and hangs



This tool-post wrench will save time when shifting the position of the tool between cuts.

along the post stub when not being used to turn the screw.

The wrench is made from two steel strips, one of which is bent to the shape of the screw head and the other to a single bend forming the handle. These parts are fastened together with a bolt, the end of which is riveted over to prevent loosening. The wrench occupies but small space, is always at hand and through its use no time is lost shifting the tool position.

Washington, D. C. G. A. LUERS.

Method of Balancing Armature by Use of Rails

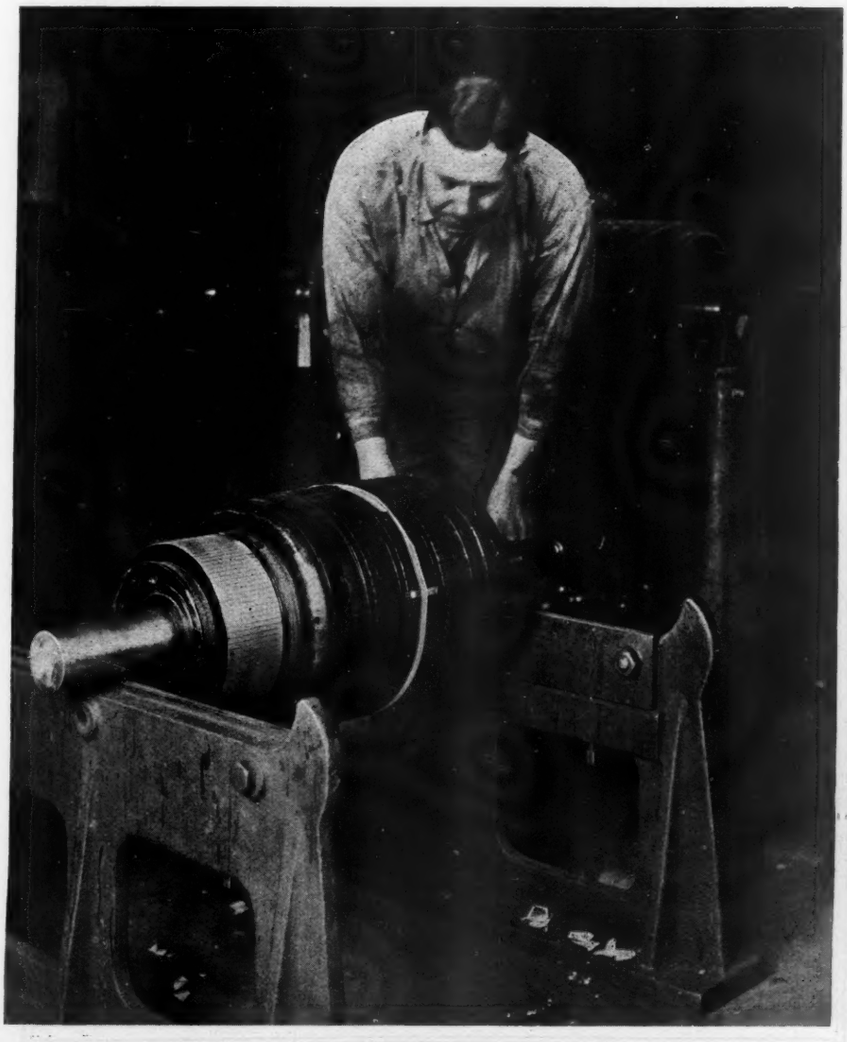
FOR the repair shop the most practical method of balancing an armature is by means of two level straight-edges or rails, as shown in the illustration. After being repaired the armature is placed with its shaft resting on the rails and is tried in several positions by rotating it until different sides are on top. If it stands still and does not tend to roll in any position, it may be considered to be balanced. If it tends to roll, the unbalance is counteracted by fastening a weight temporarily on the outside of the armature. In the illustration, this weight is a piece of ribbon solder and is held on the armature by a piece of tape. This weight must be adjusted both as regards size and position until the armature will remain at rest in any position. The location of the weight is then marked. After this, a permanent weight of the same mass as the one used for trial is permanently fastened on. In some armatures there are holes drilled for holding such balancing weights. A piece of solder of the proper weight may be placed in such a hole. In other cases, a small hole may be drilled and tapped in the spider and a weight fastened by means of a small bolt.

This method of balancing may not give satisfactory results with machines running over 1,800 r.p.m., or with very large machines running at even lower speed. In such cases, the machine should be balanced while running. A balancing machine gives the best results, of course, but this is seldom available in the ordinary repair shop.

Balancing may also be done by operating the machine without load at normal speed and marking the shaft with a piece of chalk or a pencil. This should be held at both ends of the shaft just close enough to touch on the high side if the machine is out of balance. Then the machine is stopped and weights are added on the side opposite to the marks on the shaft. In making the trials the weights may have to be put first on one end of the armature and then on the other. Various positions should be tried until the vibration when running is eliminated. It may even be necessary to put a weight on one side of the shaft at the commutator end and on the other side at the other end. This is simply a cut-and-try method and a good deal of patience is required, but by repeated trials it is usually possible to get an armature or rotor well balanced.

New York, N. Y. H. E. H.

The shaft of the armature is placed on two level and parallel rails and weight added if necessary until the armature will remain in any position without rotating.



Three Interesting Experiences in Repairing Generators

HERE are some experiences which I have had in repair work and am passing on in the hope that they may help to save time and trouble for other readers of INDUSTRIAL ENGINEER who may find a similar difficulty.

One of my interesting experiences was in a packing house where a direct-current generator would not build up. The armature had been taken out and repaired and when it was put back into service the machine would not operate. Investigation showed that the engineer had put on a new set of brushes and had sanded them to fit the commutator perfectly. The brush holders, however, were of a type in which the brushes are fastened solidly in the holder with screws. The holders had worn enough to cause the brushes to strike the commutator only at the back corners, when the machine was started. After sanding the brushes in again, being careful to pull the sandpaper only in the direction the armature turned, the machine picked up its load without difficulty.

At another time some shunt field coils for a compound-wound generator were rewound and when the fields were put in the machine would not work. When rewinding, approximately the same weight of wire had been inserted in the new coils although but little attention had been paid to the number of turns. The generator had been connected as a short shunt—that is, the shunt lead had been connected to a compound lead for a line. When the new winding showed trouble, this short shunt was changed to a long shunt by putting the shunt lead onto the armature and compound leads. The machine then built up properly. The engineer said that before this the machine had required about three minutes to build up its voltage, whereas it now takes only about half a minute. Probably the machine had been over-compounded and the resistance of the compound cut out all the voltage that the armature would generate from the residual magnetism.

On another compound-wound generator that was connected short shunt, the machine ran extremely hot. When it was changed to a long shunt, the machine ran considerably cooler. I never could understand why this was, but this is what happened when we made the change.

Peoria, Ill. GEORGE RINGNESS.

Improvements in Bearing Service

(*Continued from page 270*)

except where the sleeves are split. (6) Their starting friction is practically the same as their running friction, which is of considerable advantage. (7) Their running friction is so low, regardless of load or supply of lubricant, that appreciable power savings result.

Here it is no more than fair to plain bearings to note that their running friction, provided all conditions are perfect, is also low. The fact is that conditions seldom approach perfection for any period of time and troubles arise as conditions vary.

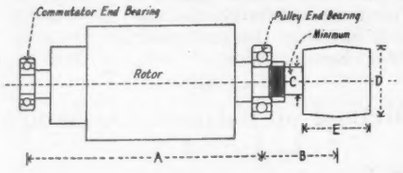
In a vertical motor, the ball bearing stands almost alone. Here thrust and radial loads are present together, with a problem in lubrication. These conditions can be met easily by a properly designed ball bearing application with no greater difficulties than the horizontal motor presents.

Further, regarding motor position, some people hang their motors upside down from the ceiling and some put them on the floor and belt up to ceiling-hung shafting. For the sleeve-type bearing, especially of the split construction dependent on oil grooves, rings, chains or wick packings, this requires some provision for moving the bearing and housings around to take care of load direction. A ball-bearing equipped motor simplifies this construction in that load direction to the ball bearing is not a factor of its satisfactory service. Plain bearings could be designed to take care of some of the above conditions. The disadvantages would be cost and lack of uniformity, each company designing their own.

Here the ball bearings are supreme in that their diameters and widths are established and their limits of accuracy standardized, each bearing of a given number being interchangeable with another of the same number even of different makes. This includes not only American but foreign-made bearings.

In conclusion the ball-bearing equipped electric motor is today serving where no other bearing has stood up. Almost universally where service conditions are unusually severe an investigation will show this is true, their selection being due entirely to the need of continuous service, other advantages being incidental.

Gurney Ball Bearing Co., Jamestown, N. Y.: This company has furnished the following table showing the sizes of bearings which they recommend for horizontal industrial electric motors.



The dimensions given in the table below refer to this diagram.

Ball Bearing Recommendations For Equipping Horizontal Industrial Electric Motors

Item No.	Motor Hp.	Speed R.P.M.	Torque Ft. Lbs.	Rotor Lbs.	Motor A	Motor B	Motor C	Pulley D	Pulley E	Bearing Loads Comm.	Bearing Loads Pul.	Bearing Sizes Comm.	Bearing Sizes Pulley
1	½	1800	1.46	12	6¾	2½	¾	2½	1½	20	57	203 Rad	204 Rad
2	½	1200	2.19	20	7½	2¾	⅞	3	2	32	80	203 Rad	205 Rad
3	1	1800	2.92							35	100	203 Rad	205 Rad
4	1	1200	4.38	30	8½	3	1 1/16	3½	2½	48	132	204 Rad	206 Rad
5	2	1800	5.84							50	160	204 Rad	206 Rad
6	1	900	5.84	40	9½	3⅜	1⅛	4	3	60	155	304 Rad	306 Rad
7	2	1200	8.76							77	222	304 Rad	306 Rad
8	3	1800	8.76							77	222	304 Rad	306 Rad
9	2	900	11.68	50	10¾	3¾	1⅜	4½	3½	95	265	305 Rad	307 Rad
10	3	1200	13.14							100	293	305 Rad	307 Rad
11	5	1800	14.60							110	323	305 Rad	307 Rad
12	3	900	17.52	60	11¾	4¼	1 1/16	5	4½	125	355	305 Rad	308 Rad
13	5	1200	21.9							145	433	305 Rad	308 Rad
14	7½	1800	21.9							145	433	305 Rad	308 Rad
15	5	900	29.2	80	12¾	4⅝	1¾	6	5	170	490	306 Rad	309 Rad
16	7½	1200	32.8							185	545	306 Rad	309 Rad
17	10	1800	29.2							170	490	306 Rad	309 Rad
18	7½	900	43.8	110	13¾	5	1⅞	7	5½	223	635	307 Rad	310 Rad
19	10	1200	43.8							223	635	307 Rad	310 Rad
20	15	1800	43.8							223	635	307 Rad	310 Rad
21	10	900	58.4	140	14¾	5½	2 1/16	8	6	273	755	308 Rad	311 Rad
22	15	1200	65.7							295	837	308 Rad	311 Rad
23	20	1800	58.4							273	755	308 Rad	411 Rad
24	15	900	87.5	170	15¾	6	2¼	9	7	357	997	309 Rad	312 Rad
25	20	1200	87.5							357	997	309 Rad	312 Rad
26	25	1800	73							317	850	309 Rad	412 Rad
27	20	900	117	210	17	6½	2	10	8	435	1207	310 Rad	313 Rad
28	25	1200	110							418	1145	310 Rad	313 Rad
29	30	1800	87.5							360	935	310 Rad	413 Rad
30	20	600	175	250	18½	7	2	10	9	610	1765	311 Rad	314 Rad
31	25	900	146							538	1400	311 Rad	314 Rad
32	30	1200	131							500	1368	311 Rad	314 Rad
33	40	1800	117							465	1235	311 Rad	414 Rad
34	25	600	219	300	20	7¾	2¾	12	10	667	1872	312 Rad	315 Rad
35	30	900	175							573	1535	312 Rad	315 Rad
36	40	1200	175							573	1535	312 Rad	415 Rad
37	50	1800	146							507	1300	312 Rad	415 Rad
38	30	600	263	350	22	8¼	2	12	11	775	2220	313 Rad	316 Rad
39	40	900	234							715	2000	313 Rad	416 Rad
40	50	1200	219							685	1890	313 Rad	416 Rad
41	60	1800	175							595	1557	314 Rad	316 DR
42	40	600	350	425	24	8	3	14	12	890	2540	314 Rad	317 Rad
43	50	900	292							792	2167	314 Rad	417 Rad
44	60	1200	263							740	1980	314 Rad	417 Rad
45	75	1800	219							665	1700	315 Rad	317 DR
46	50	600	438	500	26	9½	3	14	13	1085	3145	316 Rad	418 Rad
47	60	900	350							935	2585	316 Rad	418 Rad
48	75	1200	328							900	2443	316 Rad	318 DR
49	100	1800	292							835	2210	316 Rad	318 DR
50	60	600	525	600	28½	10	3	16	14	1170	3335	317 Rad	419 Rad
51	75	900	438							1040	2845	317 Rad	419 Rad
52	100	1200	438							1040	2845	317 Rad	319 DR
53	75	600	657	800	31	11¼	3	18	16	1410	3820	318 Rad	420 Rad
54	100	900	584							1310	3455	318 Rad	320 DR
55	125	1200	547							1263	3268	318 Rad	320 DR
56	100	600	875	1000	33½	12½	4	20	18	1740	4630	320 Rad	322 DR
57	125	900	730							1565	3970	320 Rad	322 DR
58	150	1200	657							1475	3640	320 Rad	322 DR
59	125	600	1093	1200	36	13¾	4	22	20	2055	5330	322 Rad	324 DR
60	150	900	875							1805	4430	322 Rad	324 DR

Brakes for Stopping Rotating Parts

(*Continued from page 274*)

several ways of fastening lining to the shoe. One method is to countersink the face of the shoe and drive a part of the woven lining into the countersunk space by means of copper rivets. This is the same method used in attaching automobile-brake linings. It is a very simple method and eliminates any chance of the linings loosening and at the same time permits the maximum amount of wear from the linings. Another method is shown in Fig. 7. Wooden blocks are surfaced so as to accurately fit the face of the brake wheel. The lining is glued to the surface of the blocks and is also held by countersunk brass screws. The ends of the lining lap over the ends of the wood block and are nailed thereto The block is then inserted under the lugs of the shoe.

In the disc-type brake there are two sets of friction plates; one is

known as the friction disc and rotates, the other is called the friction plate and is stationary. A cross-section of these is shown in II of Fig. 6. The rotating discs are made of steel and lined on both sides with a woven-asbestos lining. This lining is held in place by counter-sunk copper rivets. The stationary plates are made of iron and are machined on both sides.

Brake bands as used on band-type brakes are made of flexible sheet steel. There are cast or forged ears on each end of the band to provide means for anchoring the dead end and for attaching the live end to the actuating lever. The most common linings on band brakes are wood blocks, composition friction blocks, leather and woven-asbestos material. The last is probably the most used. It is fastened to the band in the same manner that has been described for shoes and discs.

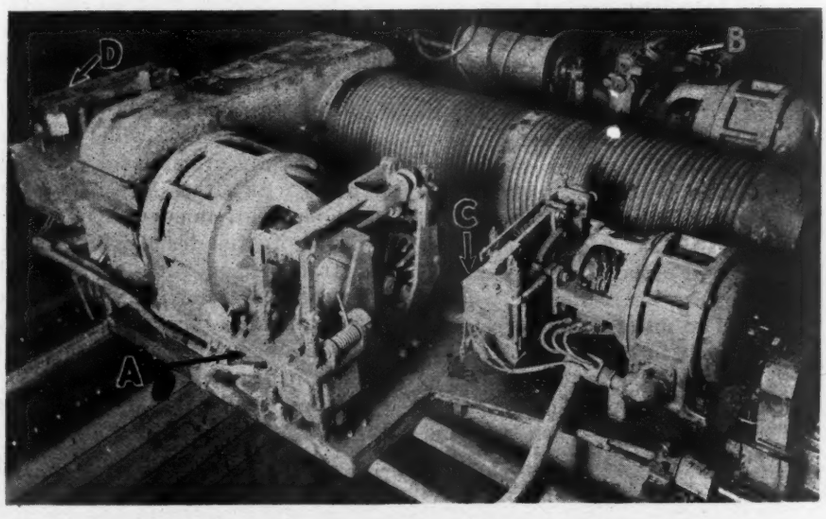
The second part of this article will appear in an early issue. In it will be discussed: brake linings; how brakes are rated; how to select brakes; data required when ordering; mounting, installation, adjusting, testing and maintenance of brakes, together with the troubles commonly experienced with them.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for assistance in furnishing information, data and illustrations for this article: Allis-Chalmers Mfg. Co., Milwaukee, Wis.; E. C. Atkins & Co., Indianapolis, Ind.; Commercial Chemical Co., Boston, Mass.; Cutler-Hammer Mfg. Co., Milwaukee, Wis.; Electric Controller & Mfg. Co., Cleveland, Ohio; General Electric Co., Schenectady, N. Y.; Kelso Mfg. Co., Trenton, N. J.; Sundh Electric Co., Inc., Newark, N. J.; Thermoid Rubber Co., Trenton, N. J.; Tool Steel Gear and Pinion Co., Cincinnati, Ohio; Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa.

In compiling this article information has been obtained from a chapter on electric brakes in a new book, "Principles of Electric Motors and Control," by Gordon Fox, published by the McGraw-Hill Book Co., and also from an excellent paper, "Auxiliary Electrical Equipment for Motor-Operated Cranes," presented before the A. I. E. E. in 1922 by H. W. Eastwood.

Fig. 10—At (A) and at (B) are multiple-solenoid brakes which give graduated braking.

These brakes are in use on wound-rotor, induction motors driving the main hoist and the auxiliary hoist of a 15-ton crane. At *C* is an alternating-current solenoid brake operating on the trolley motor of the crane. *D* is an emergency brake for the main hoist.



Improving Wiring Around Machinery

(*Continued from page 281*)

National Electrical Code specifies that there shall not be more than the equivalent of four quarter-bends between two consecutive outlets or fittings, the bends at the outlets not being counted.

Bending of conduit should be avoided wherever possible; standard elbows or condulet fittings are preferred. Although the material cost of doing the job in this way may be high, the increased labor cost and spoiled material resulting from complicated conduit bending may counterbalance this.

When using large wire, such as No. 00 in the 2-in. and larger sizes of conduit, use rear-cover condulets instead of those having covers on the side. With condulets having covers on the sides, it will be found almost impossible to force the wire through the outlets unless extra flexible wire is used, because of the small working space between the side outlet and the side of the condulet opposite the outlet.

Flexible metallic conduit is a great labor saver in tight quarters where several odd bends are required. It is also useful in places subjected to vibration that would loosen rigid conduit. It is the ideal connecting link between the motor condulet and the nearest solid support such as the ceiling, floor or wall where the rigid conduit begins.

Don't locate conduit too conspicuously, yet have it accessible. Conduit running across a floor should be buried below the surface or carried overhead and not run as conspicuously as shown in illustration *F*, page 276. Conduits running beside each other should be parallel and the bends in them should match. There is nothing more unsightly or more indicative of poor workmanship than four or five conduits running together, each with uneven and unequal bends. Conduits should be kept as close to the wall as possible, in the structural work, along the ceiling and the like, rather than run exposed with no protection.

In industrial works, all open work or knob-and-tube work should be avoided. Conduit work and underground cable work have been proved to be worth far more than the additional cost, in mills and factories.

Every so often some wireman will install a condulet having a cover, so that it is covered with cement, thus making it impossible to pull wires in or out without knocking a hole through the cement. It is a foolish thing to do, but it is done; so I mention it in passing. There are special condulets made for concealing in concrete, which have smooth bends similar to elbows and made without handholes and covers. Some wiremen use loom in exposed locations to protect wires that would otherwise be bare. That idea is all right, but the application of it is not. Flexible metallic conduit should be used in such places in the industrial plant.

The cost of wiring a given installation should be the last consideration in the layout of the job. Good wiring does not cost a great deal more than poor wiring and yields large returns in the form of decreased maintenance cost, less production delays, and fewer accidents.

EDITOR'S NOTE: Special acknowledgment is made to the Brunswick-Kroeschell Co., Chicago, Ill., for some of the pictures which show the excellent wiring in its factory, and to C. V. Putnam of the Reliance Electric & Engineering Co., Cleveland, Ohio, for suggestions and assistance in obtaining many of the illustrations used.

Best Ways to Use Insulating Varnish

(Continued from page 287)

loosened in service are tightened up and the coils are cemented in place.

Method of Securing Resistance to Acid

Resistance to acid fumes may be obtained by the same general process of treatment as has been outlined before. Thorough protection can only be expected when a smooth, glossy coat has been secured having no breaks in the continuity.

Method.—When the acid conditions are severe from two to four baked coats followed by heavy applications of suitable air-drying products will produce excellent results. The quick air-drying products, while quite unaffected by dilute hydrochloric or sulphuric acids, crack in service and allow the acid to get in under the film and actually lift the varnish from the surface. It is, therefore, better to use less brittle, slower-drying materials even at the expense of some slight increase in production cost.

Of the three major active acids hydrochloric and sulphuric are the easiest to protect against. Nitric acid on the other hand is much more powerful and will destroy any varnish so far made. When nitric acid fumes are present and all of the foregoing precautions have been taken in the treatment, it is best to go over the apparatus periodically and neutralize the acid by washing with a dilute alkali solution. The added maintenance expense is well worth while because when properly done this operation will prevent the necessity of frequent re-winding operations.

Providing Resistance Against Oil

This problem is similar to the other two insofar as treatment is concerned. The chief difference is in the choice of a suitable varnish. While one material may work well for both of the other problems it will not be at all adapted for extreme conditions such as are experienced in oil-cooled transformers. It is best in this case to consult the varnish manufacturer and select that material which has been designed for this purpose. Resistance to oil can be obtained only when the coils are completely and perfectly sealed and the varnish film baked until it is dry and hard. The soft, flexible materials become oil resisting only when they are baked for a sufficiently long period or at a sufficiently high temperature so that they lose, to some extent, their flexibility and become as hard as those products having shorter life.

Any product that will withstand transformer oil will withstand machine oil. Many materials that will not resist the former will be entirely suited for protection against the latter.

As a finishing coat over baked films, to secure additional protection, the alcohol-solvent varnishes are entirely suitable. They are very impervious to oil, but it must be borne in mind that they become insulators only when thoroughly dry and allowance must be made for this fact in the testing of the completed apparatus.

In selecting materials for these three classes of work remember that acid-resisting products are generally water resisting also, but they are not absolutely acidproof.

Protecting Against Metallic Dust

In most cases protection against metallic particles, carbon dust, etc., has been secured automatically when other conditions have been fulfilled. When conditions are extreme it is sometimes necessary to adopt extreme measures. A hard, smooth surface will prevent these particles from adhering and cutting their way through the insulation. This may usually be obtained by the use of a hard, air-drying varnish as an outer covering. When difficulty is still experienced it may be overcome by the use of a hard-setting cement which may be prepared in the shop.

General Remarks.—It must be remembered in reading the foregoing that we have been dealing with each problem separately and considering each condition as extreme. It is hoped that the reader will be able to adapt the procedure to his own individual needs. The problems seldom come singly. In motor treatment, for instance, we do not usually have to protect against moisture alone. Some oil will be splashed upon the windings. Furthermore, it is not always certain that the motor will not be placed in an atmosphere containing some acid fumes. Again, it may be used to drive a grinding or buffing machine where the metallic particles will be thrown upon the windings. Also the design of the armature may require that the varnish be the principal factor in holding the coils in the slots. A varnish for such service must, therefore, combine all of the characteristics which we have described. It must sacrifice protection in some directions for increased protection in others.

Another section of this article will take up conductor corrosion and other varnish problems.

Testing Insulation of Windings

(Continued from page 283)

Whether conditions of this sort can be maintained and whether such a test is desirable are questions difficult to answer. Not until operating conditions are standardized and operators' ideas on the subject correlated, can a satisfactory answer be obtained. The following tests have been used successfully under various operating conditions.

After the generators have been carefully examined and thoroughly cleaned they should be run on open circuit with sufficient excitation to raise the terminal voltage about 25 per cent above normal for five minutes. After the test, the voltage is reduced to normal and the several terminals grounded in succession. In making this test, arrangements must be made to break the field current instantly in case of failure.

This test is more searching than the application of an equivalent alternating-current potential from a testing transformer. The latter or so-called high-potential test is usually made between the windings and ground, whereas the generated voltage test described is in reality a test from turn to turn, from coil to coil, and from phase to phase.

A test frequently used on the windings of revolving fields is to subject them to two or three times normal exciting voltage, applied between one terminal and the shaft. The test should be applied while the field is running at normal speed and may be made with either direct or alternating current, as convenient.

High-potential tests using a testing transformer vary widely with different operators. Tests are required on armatures ranging from 10 to 60 per cent over normal and are applied for periods of time varying from one to thirty minutes. On revolving fields, voltages up to six times normal are applied for widely varying periods.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

The Borden Company, Warren, Ohio—A folder describes the new 106, 108 and 112 Beaver pipe cutters. These not only cut the pipe square without burrs, as do the other Beaver cutters, but are operated on a different principle which permits the operator to cut the larger sizes by hand quickly and easily.

Armstrong Brothers Tool Company, 317-357 North Francisco Avenue, Chicago, Ill.—Catalog B-23 covers the new line of pipe tools, dies, stocks, cutters and chain wrenches as well as a line of tool holders, ratchet drills, wrenches and other machine shop equipment.

Independent Pneumatic Tool Company, 600 West Jackson Boulevard, Chicago, Ill.—This company announces a new Thor reversible electric tapping machine, size UKR, for tapping small holes up to 3/16 in., and for retapping larger sizes up to 5/16 in. The reverse is strictly mechanical and so is claimed to eliminate the shock to the armature, which often occurs when a drill is reversed by electric current.

Crouse-Hinds Company, Syracuse, N. Y.—Bulletin 2054 describes condulets of the FA series. These condulets are provided with tumbler switches and covers and are designed for industrial purposes.

The Johns-Pratt Company, 160 Huyshope Avenue, Hartford, Conn.—A new folder entitled "Going Under Ground" describes some of the Noark underground boxes fitted with Noark fuses which it is claimed simplify installation, give a watertight construction for the protection of fuses in cable connections and safeguard against mechanical injury in underground transmission and distribution systems.

Janette Manufacturing Company, 556-558 West Monroe Street, Chicago, Ill.—A series of monthly bulletins entitled "Janette Talks" are issued and mailed to those interested as a medium of interest and a means of presenting the advantages of Janette special motors.

Industrial Controller Company, Milwaukee, Wis.—A circular illustrates the construction and operation of the Class 8605 oil-immersed automatic compensator. Two special features claimed for this are the conduit section for easy wiring and the accessibility of all contacts and connections.

Acme Electric Heating Company, Boston, Mass.—Loose-leaf sheets describe the special electric industrial heating appliances such as embossing-press heaters, cast-iron glue pots, sealing-wax pots, pots for melting metal, pitch kettles, melting ladles, cartridge heaters, and special laboratory heating devices.

General Electric Company, Schenectady, N. Y.—Bulletin 67100-A describes the construction and gives the various applications of safety enclosed, removable, truck-type switchboards.

Winfield H. Smith, 10-16 Lock Street, Buffalo, N. Y.—Catalog 21 gives specifications and prices, with illustrations, of a line of pulleys, arbor presses, reducing gears and revolving display tables manufactured by this company. These are all made for light service, such as in sewing rooms, in model work and in special display work.

The Ohio Electric and Controller Company, Cleveland, Ohio—A folder describes the Ohio motor-generator set designed primarily for charging small batteries. The generator may, however, be wound for any direct-current voltage up to 250 and used for intermittent or continuous service, such as signal or clock service system, or other work requiring a direct-current voltage not otherwise available.

The Esterline-Angus Company, Indianapolis, Ind.—Bulletin 324 entitled "Graphics Pay in Small Plants Too," shows how graphic meters in one small plant found a $4,000 waste of power by a defective 3-hp. motor. Other items discussed are the use of graphic records to create morale and for correcting low power factor.

General Electric Company, Schenectady, N. Y.—Circular 657-1, Class 15, describes the type IK-108-Y1 and type IK-109-Y1 polyphase induction reverse power (power directional) relays which are recommended for protection against power feed back on lines operating under a condition of leading power factor. These relays are for operation on 25- to 60-cycle circuits where the power factor may vary from approximately zero (90 deg.) leading to 0.17 (80 deg.) lagging.

The American Floor Surfacing Machine Company. 518 South Sinclair Street, Toledo, Ohio—A large folder describes the applications which may be made of the American Universal Floor Surfacing Machines in the treatment of new or old floors.

John C. Dolph Company, Newark, N. J.—A folder describes the Dolph Chinalak black baking insulating varnish and tells how it may be used to the best advantage. A price list is also given of the various other insulating varnishes manufactured.

The Pelton Water Wheel Company, Nineteenth and Alabama Streets, San Francisco, Calif.—Bulletin 19 describes the Pelton water wheels (impulse turbines), their construction and some of the various applications.

Mutual Electric and Machine Company, Detroit, Mich.—Bulletin 25 describes the "Bulldog" super-safety switchboard, industrial type, model DF5 with dead front. Both front and rear views are shown of several different switchboard installations.

Bethlehem Steel Company, Bethlehem, Pa.—Catalog M describes the large unit-type of Bethlehem oil engines for marine and stationary service. In addition to a thorough description of the construction and operation, space is devoted to the advantages claimed, rating and the result of an endurance run.

Crouse-Hinds Company, Syracuse, N.Y.—A large folder describes the FS series of condulets which are made in two-, three- and four-gang parallel and two-gang tandem for switch and plug receptacle outlets in vapor-proof and non-vapor proof types.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—An 8-page circular, C-1694, entitled "Supervisory Control" gives the general principles of operation and construction of both audible and visual systems of supervisory control for automatic substations.

Diehl Manufacturing Company, Elizabeth, N. J.—Circular 1012 D125 contains a brief description of the various types of motors made by this company together with a condensed price list of the most frequently called for standard apparatus. It also includes various types of exhaust fans as well as desk, bracket, ceiling and belted fans.

Bailey Meter Company, 2015 East Forty-sixth Street, Cleveland, Ohio—Bulletin 200 shows the application of the Bailey tachometers to indicate and record the speed of turbines, stokers, paper machines, fans, centrifugal pumps and other equipment.

Foote Brothers Gear and Machine Company, 213-223 North Curtis Street, Chicago, Ill.—A folder entitled "Reducing Motor Speeds—A Better Method" shows several applications of the Foote IXL spur-gear transformers which may be used to give a reduction of from two-to-one to five hundred-to-one or more, and IXL worm-gear transformers for heavy service.

Foamite-Childs Corporation, Turner Street, Utica, N. Y.—Bulletin entitled "Industrial Fire Chief," published in magazine form, shows many of the industrial applications of Foamite as a fire extinguisher.

The American Time-Switch Company, Commercial Building, Cleveland, Ohio—Folder B gives a description of the operation, construction and types of American time-switch clocks as well as some of the various uses to which they may be applied. These will turn current on or off automatically at any pre-determined time and are used for controlling lights, signs, alarm systems, storage battery charging or the operation of isolated motors.

The Hertner Electric Company, West One Hundred and Twelfth Street, Cleveland, Ohio.—Bulletins 5561-62-63-64-65-66 describe the individual motor-generator sets and automatic panels for constant-current charging of individual and multiple Edison

batteries and taper charging of individual and multiple lead batteries. In addition to numerous other charging data, another special feature is tables giving the approximate hours required to recharge lead batteries.

Liteweld Company, 2400 Woodland Avenue, Cleveland, Ohio—A circular describes the Liteweld track bonder and welder which is mounted on a light frame of steel tubing and angle iron and supported on pneumatic-tired, 30-in. wheels so as to give portability. While this device is made primarily for track work, it has many other applications where portability is desired.

B. E. Coil Former and Tool Company, 122-130 Centre Street, N. Y.—A circular illustrates and describes the Townsend combination coil winder and spreader which it is claimed does away with the use of home-made wooden forms and pulling blocks. Immediately after the coil is wound it is pulled on the same machine and is ready for the taper.

The Hayward Company, 50 Church Street, New York, N. Y.—Pamphlet 620 describes the Hayward automatic take-up cable reels and cable couplers for use in connection with motor buckets or electric magnets when used on a locomotive or traveling crane to prevent accidents, wear or short circuits due to the sagging of the conductor cables. The reel operates on the principle of an ordinary shade roller with the rotating power supplied by a set of compounded springs which are enclosed within the drum.

American Di-Electrics, Ltd., 466 East Seventh Street, Brooklyn, New York.—Price list 123 lists, with the price, the various electrical insulating varnishes and compounds made by this company and gives instructions for their use.

The Arrow Electric Company, Hartford, Conn.—A circular entitled "It Won't Come Out," shows the various types of Arro-Grip sockets for industrial plants, mills and shops. The special feature of this socket is that it is constructed to take the strain off the binding posts and prevent shorts from fraying wires. It also provides a strong wiring device for holding up reflectors or heavy fixtures.

The Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio—A circular lists the various types and sizes of Imperial commutator stones and commutator-grinding tools.

Burke Electric Company, Erie, Pa.—In bulletin No. 127 details are given of variable voltage types of arc welding outfits of portable and stationary design. A 400-amp. equipment is made that two operators can use on the same job or on different classes of work without interference, or one operator may use the full capacity of the set. The Burke Electric Company has recently opened a branch service and sales office in Chicago with M. E. Standish as manager at 310 South Michigan Blvd., Chicago, Ill. This company makes a full line of direct- and alternating-current motors and generators for power stations and all classes of industrial service.

Practical Books

For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

Practical Electro-Plating—By W. L. D. Bedell. Fifth edition, Distributed by The Hanson and Van Winkle Company, Newark, N. J. 407 pages, illustrated. Price $3.00.

It has been the author's aim in compiling this work to instruct the operator, in a practical manner, in the art of electro-plating, polishing, buffing, and metal finishing. This book illustrates and describes the necessary equipment and supplies, states what they are used for, and how to use them. The general shop arrangement is first described; then, beginning with the installation of the generator, the complete electrical equipment is considered in the order in which it should be set up and connected. Other necessary equipment and information is given in regular order.

In the electro-deposition of the standard commercial metals, formulas are given for making and operating various plating solutions, dips, and pickles, as well as the manner in which they should be maintained and renewed.

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Cast-Iron Welding by the Oxy-Acetylene Process—Compiled and published by the Linde Air Products Company, 30 East Forty-second Street, New York, N. Y., 115 pages, illustrated.

The purpose of this booklet is to give the proper application of the accepted practices in oxy-acetylene welding of cast iron toward the solution of various problems. Among the subjects treated are: Nature and properties of gray cast iron, application of welding to cast iron, equipment, preparation, preheating, welding, annealing, finishing, testing welds, estimating welding cost, and some typical cast-iron welding jobs. An appendix gives ten practical problems in cast-iron welding and shows how they may be solved. The book is well illustrated with both halftones and drawings throughout.

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Diesel Engines—By Lacey H. Morrison of the editorial staff of Power. Published by McGraw-Hill Book Company, 370 Seventh avenue, New York City, 598 pages, 385 illustrations. Price $5.00.

The increase in the cost of power in coal-burning power plants has caused many to give serious consideration to the Diesel engine. This book not only gives a complete and comprehensive statement of the use, construction, operation, maintenance and repair of Diesel engines, but also gives a wealth of data on its economic status in the public utility and industrial fields. A chapter is devoted to a detailed discussion of initial costs, labor costs, maintenance charges, fuel consumption and actual operating and production results. A short history of the development of the Diesel engine is given. The body of the book is devoted to a practical discussion of the various types of engines from the standpoint of frames, cylinders, pistons, connecting rods, crank shafts, bearings, valves, fuel pumps and governors. Chapters of particular value are those on: installation, in which step-by-step methods of erection are given; cooling systems, in which advanced methods of cooling are described together with means of reclaiming the exhaust heat; Diesel fuel oils; and one on indicating the Diesel engine, in which is given a thorough analysis of Diesel engine indicator diagrams. In this connection there is given not only a discussion of indicators particularly adapted to the Diesel engine, but also the manner of rigging the indicator, the errors to avoid, and the interpretation and study of the diagram. The book is written in a manner that will appeal to those having anything to do with the selection, purchase, management or operation of the Diesel engine.

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Supervision and Maintenance of Steam-Raising Plant—By Charles A. Suckan. Published by The Van Nostrand Company, 8 Warren Street, New York City, 326 pages, illustrated. Price $8.

In the preface of this book the author points out that a new type of engineer is coming into being; namely, the combustion engineer or engineer-chemist whose function it is to assist power plant owners, managers and engineers in the efficient operation of steam-raising plants under existing conditions. The book has been prepared as a handy work of references with all information presented in simple form and the discussions of the theoretical side of the subject reduced to a minimum. It is divided into two parts; the first deals with the supervision and actual working of a plant while the second takes up repairing and general overhauling.

In the first part the following subjects are dealt with: (1) details of the boiler plant; (2) combustion of fuel; (3) method of firing; (4) regulation of draught; (5) superheaters; (6) economizers; (7) pumps, injectors, and meters; (8) handling of fuel; (9) handling of ashes; (10) feed water plant; (11) pipe system; (12) routine of boiler-house staff; (13) office staff; (14) testing.

The second part, devoted to maintenance, discusses the following subjects: (15) internal inspection; (16) external inspection; (17) boiler brickwork; (18) "laying up"; (19) auxiliary appliances; (20) auxiliary plant brickwork; (21) workshop organization; (22) feed-water plant; (23) pipe lines; (24) structural repairs; (25) conclusion.

There are 250 illustrations of equipment and installation details which make it easy to understand the practical points which the text describes.